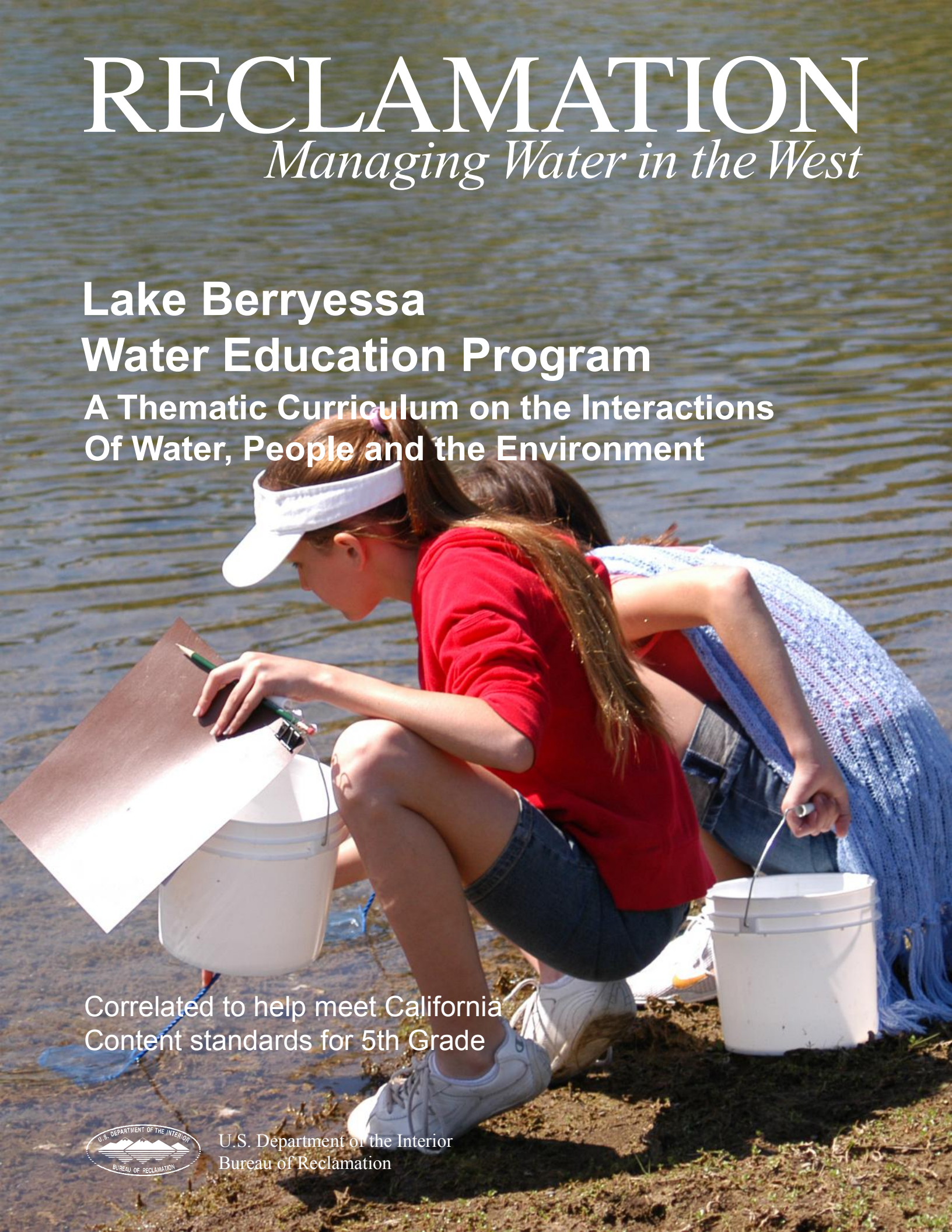
RECLAMATION

Managing Water in the West

Lake Berryessa Water Education Program

A Thematic Curriculum on the Interactions Of Water, People and the Environment



Correlated to help meet California Content standards for 5th Grade

U.S. Department of the Interior
Bureau of Reclamation

The Program is sponsored by the Bureau of Reclamation whose mission it is to:

Manage, Develop, and Protect Water and Related Resources in an Environmentally and Economically Sound Manner in the Interest of the American Public.

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To The Teacher

Introduction

Thank you for participating in the Lake Berryessa Water Education Program. The program provides an interdisciplinary learning experience for students, integrating the natural resources of the lake with California curriculum standards. This program is intended to allow students and teachers to experience a positive day of fun by emphasizing hands-on learning. The curriculum-based activities will help students to gain an appreciation and understanding of water resources. The program is also intended to inspire wise stewardship of public resources, good conservation practices at home and to provide enthusiasm to re-visit Lake Berryessa and experience the natural resources with family and friends.

The theme of your program is "Lake Berryessa: Protecting Your Future, One Drop at a Time!" Students will understand the value of water resources in their community; the importance of fresh water quality and quantity for all living things; explore water impacts and water conservation methods; and learn about the Bureau of Reclamation's mission in providing water to the community.

The pre-site lessons and pre-assessment included in this packet are specific to the goals and learning objectives of the program, and should be presented prior to the scheduled visit. The on-site activities are conducted by the Park Ranger with your assistance in discussion and discipline. Post-site lessons are designed to augment and reinforce field visit experience. A Park Ranger is available for school visits to conduct both pre and post site lessons (materials necessary for these lessons will be provided). Please feel free to contact us at 707-966-2111 ext. 112 if you have further questions about the program and scheduling.

Classroom Parameters

Important Reminders for a Successful Program

Maximum Group Size: 60 (two classes of 30 will be split in two for activities, 30 per Ranger)

CA Curriculum Standards: Meets 5th grade standards for Earth Science, Investigation and Experimentation, Mathematics, English-Language Arts; and review of 4th grade Life Science standards.

Field Visit Site: Oak Shores Day Use Park/Coyote Knolls: 5550 Knoxville Road, Napa, CA 94558

Rain Site Option: Oak Shores Day Use Park/Coyote Knolls Shade Shelters (severe weather may require re-scheduling trip due to hazardous road or extreme cold conditions)

Learning Strategies: Hands on scientific data gathering; practice in scientific reporting methods; hands on games to emphasize concepts of water users, water cycle, and watersheds; classroom mapping and research activities

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Field Visit Logistics

Name Tags/Groups: Please provide name tags and designate each class into 3 smaller groups for on-site activities prior to arriving (small groups/class of 30). In addition, have 1 chaperone for each small group of 10 students.

Student Materials: Please have students bring pencil/pen and paper. All other materials pertaining to the on-site lessons will be provided.

Map: A map of Lake Berryessa and a color brochure of the *Oak Shores and Smittle Creek Day Use Area,* which contains a map of the field visit site, are included in this packet. If you need specific directions to the outdoor classroom/field site, please contact us at 707-966-2111 ext. 112.

Where to Meet: All students, teachers, and chaperones will meet the Park Ranger at the Oak Shores Day Use Park Entrance Station. The Park Ranger will then direct the bus to the Coyote Knolls parking area, introduce him/herself, state the theme of the program, and explain where and how the program will be conducted. The program includes a short walk between activity sites and ½ mile walk on a nature trail. The program will begin at the time established by the Park Ranger and Teacher during scheduling (see Example Day Plans by Drive Time on page 4).

Safety: A color brochure titled *Planning for a Safe Visit to Lake Berryessa* has been included in this packet. Please look it over in preparation for your visit. A brief safety talk will be given to the students upon their arrival to the park.

Weather Concerns: Students should be prepared to spend up to 3 hours outdoors in local weather conditions, which vary during fall/spring in the Coastal Range from warm and dry to cold and rainy. Teachers should check local weather for Napa, which is usually similar to Lake Berryessa conditions. Advise students to wear closed-toe shoes and dress in layers, so they can remove clothing if it is warm or add clothing if weather becomes cooler while on-site (clothing should be durable to outdoor conditions). This program will be conducted under the Coyote Knolls shade shelters in mildly inclement weather, and may be cancelled due to extreme cold or rain conditions.

Please contact the Park Ranger at 707-966-2111 ext. 112 prior to school departure if you have any questions about weather or delayed arrival. The Ranger will contact you prior to school departure if weather conditions warrant re-scheduling the program.

Restrooms: Restrooms and a drinking fountain are available near the bus parking in Coyote Knolls.

Lunch: Lunches will be eaten as a group on the grass or at picnic benches in and around the Coyote Knolls area. Teachers may either pack lunches in a few large boxes to be carried by chaperones to the lunch site, or may have students carry individual lunches and drinks in backpacks through the program. Lunches and drinks are provided by the students.

Special Needs: Please inform the Park Ranger during your program scheduling if you have any students with special needs or medical conditions that you would like for us to accommodate during your field visit. We may be able to adjust program locations and activities to accommodate those needs.

Discipline: The teacher is responsible for discipline during the program.

Chaperones: Chaperones will be responsible for a small group of students, including maintaining discipline, student safety, and helping students complete on-site activities and games. Please provide 1 chaperone per 10 students, with a minimum of 3 chaperones per class of 30.

Cancellations: Should anything unforeseen occur that prevents you from keeping your scheduled field trip, please contact the Park Headquarters at 707-966-2111 ext. 100 or 112 to notify us of your cancellation. If you need to contact us on the day of the trip for late arrival or other information, please call the Park Ranger at 707-966-2111 ext 112.

Example Day Plans By Drive Time:

(Schools with 30 minute drive time – Capell Valley/Pope Valley)
9:00 - Leave School
9:30 – Arrive Lake Berryessa Oak Shores
9:30 – 9:45 – Welcome from Ranger, safety talk, unload bus, restrooms
9:45 – 10:00 – Introduction and walk with Ranger to program site
10:00 – 10:45 – ½ group Activity 1/ ½ group Activity 2 & 3
10:45 – 10:50 – switch groups
10:50 – 11:35 – ½ group Activity 1/ ½ group Activity 2 & 3
11:35 – 12:10 – Lunch as a group/restrooms as needed
12:10 – 1:00 – Interactive Nature Walk and Group Conclusion with Ranger
1:00 – 1:15 - Load bus, restrooms as needed
1:15 – 1:45 – Return to School

(Schools with 1 hour drive time – Napa/Winters)
8:45 - Leave School
9:45 – Arrive Lake Berryessa Oak Shores
9:45 – 10:00 – Welcome from Ranger, safety talk, unload bus, restrooms
10:00 – 10:15 – Introduction and walk with Ranger to program site
10:15 – 11:00 – ½ group Activity 1/ ½ group Activity 2 & 3
11:00 – 11:30 – Lunch as a group/restrooms as needed
11:30 – 12:15 – ½ group Activity 1/ ½ group Activity 2 & 3
12:15 – 1:00 – Interactive Nature Walk and Group Conclusion with Ranger
1:00 – 1:15 - Load bus, restrooms as needed
1:15 – 2:15 – Return to School

(Schools with 2 hour drive time – Sacramento/Bay Area)
9:00 - Leave School
11:00 – Arrive Lake Berryessa Oak Shores
11:00 – 11:15 – Welcome from Ranger, safety talk, unload bus, restrooms
11:15 – 11:30 – Introduction and walk with Ranger to program site
11:30 – 12:00 – Lunch as a group/restrooms as needed
12:00 – 12:45 – ½ group Activity 1/ ½ group Activity 2 & 3
12:45 – 12:50 – switch groups
12:50 – 1:35 - ½ group Activity 1/ ½ group Activity 2 & 3
1:35 – 2:15 – Interactive Nature Walk and Group Conclusion with Ranger
2:15 – 2:30 - Load bus, restrooms as needed
2:30 – 4:30 – Return to School

The duration and logistics of the program can be adjusted to meet individual school needs.

Goals and Objectives

Theme: Lake Berryessa: Protecting your future, one drop at a time.

The Bureau of Reclamation has established four program goals to accomplish. Specific learning objectives are listed under each goal. Pre-site, on-site, and post-site lessons are designed to meet one or more of the program goals and learning objectives.

Goals:

I. **Students will understand the value of fresh water in their lives and in their community.**
   A. Students will learn through demonstration and discussion the limited availability of freshwater on earth.
   B. Students, through activity, will learn the importance of the water cycle (including terminology specific to the cycle).
   C. Students will explore the variety of uses that water has in their community (i.e. agriculture, domestic, recreation, ecosystem, scenic value).
   D. Students will be able to identify the geographical components of the watershed in their community.

II. **Students will understand the importance of water quality and water quantity and the effect on the ecosystem.**
   A. Students will identify how human activities affect freshwater systems directly or by impacting the watershed.
   B. Students will gather data on important water quality indicators.
   C. Students, through activity and investigation, will examine the impacts of water quality and quantity on the ecosystem.

III. **Students will have an appreciation of their own impact on water resources and will understand the importance of conserving this valuable resource.**
   A. Students will speculate on how present water quality impacts can affect future water use.
   B. Students will learn through activity and discussion
   C. The importance of water conservation and wise water use.

IV. **Students will understand the role of the Bureau of Reclamation in bringing water to California and the Western half of the United States.**
   A. Students will determine where their local water resources originate and the role of the Bureau of Reclamation in their area.
   B. Students will become familiar with the dams, reservoirs and aqueducts that supply water to California communities.

Curriculum Correlations

In recent years California has adopted academically rigorous content standards in core subject areas. The knowledge and skills students need to acquire are explicitly stated for most grade levels. To help students achieve at high levels, local educators and community partners have taken these standards and designed specific curriculums and instructional strategies that best deliver the content to the students.

The Lake Berryessa Water Education Program is a curriculum designed to help meet California State content standards for Grade Five, the academic level that focuses on water awareness. Science content, under the "Earth Sciences" and "Investigation and Experimentation" standards, is the core of the program. Additional content in the areas of math and English-language arts and a review of Grade Four science standards are covered within the program's framework. Below are the California Department of Education content standards that this curriculum incorporates. Each activity description is referenced to academic standards by specific subject, number and letter coding.

GRADE FIVE

SCIENCE
Earth Sciences

3. Water on earth moves between the oceans and land through the processes of evaporation and condensation. As a basis for understanding this concept:
- **a.** Students know most of the Earth's water is present as salt water in the oceans, which cover most of the Earth's surface.
- **b.** Students know when liquid water evaporates; it turns into water vapor in the air and can reappear as a liquid when cooled or as a solid if cooled below the freezing point of water.
- **c.** Students know water vapor in the air moves from one place to another and can form fog or clouds, which are tiny droplets of water or ice, and can fall to Earth as rain, hail, sleet, or snow.
- **d.** Students know that the amount of fresh water located in rivers, lakes, under-ground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.
- **e.** Students know the origin of the water used by their local communities.

Investigation and Experimentation

6. Scientific progress is made by asking meaningful questions and conducting careful investigations.
- **a.** Classify objects (e.g. rocks, plants, leaves) in accordance with appropriate criteria.
- **b.** Develop a testable question.
- **c.** Plan and conduct a simple investigation based on a student-developed question and write instructions others can follow to carry out the procedure.
- **f.** Select appropriate tools (e.g., thermometers, meter sticks, balances, and graduated cylinders) and make quantitative observations.
- **g.** Record data by using appropriate graphics representations (including charts, graphs, and labeled diagrams) and make inferences based on that data.

h. Draw conclusions from scientific evidence and indicate whether further information is needed to support a specific conclusion.

MATH

Number Sense

1.0 Students compute with very large and small numbers.

1.2 Interpret percents as a part of a hundred.

2.4 Understand the concept of multiplication and division of fractions.

2.5 Compute and perform simple multiplication and division of fractions and apply these procedures to solving problems.

Mathematical Reasoning

1.0 Students make decision about how to approach problems.

1.1 Analyze problems by identifying relationships, distinguishing relevant and irrelevant information, sequencing and prioritizing information, and observing patterns.

1.2 Determine when and how to break a problem into simpler parts.

ENGLISH-LANGUAGE ARTS

Reading

1.0 Students use their knowledge of word origins and word relationships, as well as historical and literary context clues, to determine the meaning of specialized vocabulary and to understand the precise meaning of grade level appropriate words.

1.2 Use word origins to determine the meaning of unknown words.

Listening and Speaking

1.0 Students deliver focused, coherent presentations that convey ideas clearly and relate to the background and interests of the audience. They evaluate the content of oral communication.

1.1 Ask questions that seek information not already discussed.

1.2 Interpret a speaker's verbal and nonverbal messages, purposes and perspectives.

1.3 Make inferences or draw conclusions based on oral report.

1.4 Select a focus, organizational structure, and point of view for an oral presentation.

1.5 Clarify and support spoken ideas with evidence and examples.

1.6 Engage the audience with appropriate verbal cues, facial expressions, and gestures.

1.7 Identify, analyze, and critique persuasive techniques; identify logical fallacies used in oral presentations and media messages.

GRADE FOUR

SCIENCE

Life Sciences

3. Living organisms depend on one another and on their environment for survival.
   a. Students know ecosystems can be characterized by their living and nonliving components.
   b. Students know that in any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

Earth Sciences

5. Waves, wind, water, and ice shape and reshape Earth's land surface.
   a. Students know some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
   b. Students know moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places.

Name: _____ **Date:** _____

Pre / Post Program Assessment

What do you know about Lake Berryessa? _____
_____

Circle the best answer. Do you go to the lake 1. every two or so years; 2. once a year; 3. two times a year; 4. more than two times a year; 5. never

Why do you come to the lake and what do you like to do best? _____
_____

Is Lake Berryessa a special place to you and if so, why? _____
_____

Circle the letter of the correct answer.

1. How much of the earth's water is fresh and can be used by people?
   (A) Most of the earth's water is fresh and can be used by people.
   (B) All of the earth's water is fresh and can be used by people.
   (C) A tiny amount of the earth's water is fresh and can be used by people.

2. Which one of these statements does **not** refer to the water cycle.
   (A) Movement of water through a liquid, solid and gas state.
   (B) A new motorcycle that runs on water.
   (C) A process by which water moves between the land, air and ocean.

3. Why is the water cycle important?
   (A) It provides fresh water for living things by recycling water.
   (B) It provides salty water for living things by recycling water.
   (C) It does not recycle water on the earth's surface.

4. A watershed is:
   (A) A small shed built in the mountains to hold water.
   (B) A region or land area drained by a river or stream.
   (C) Another name for a well deep underground.

5. What is the purpose of a watershed?
   (A) To predict the weather.
   (B) To absorb, store and filter water.
   (C) To prevent water from soaking into the ground.

6. What can people do to help protect a watershed?
   (A) Avoid polluting the land and water.
   (B) Be careful not to start fires.
   (C) Plant trees and other plants to keep the soil from eroding.

(D) All of the above

7. Which of the following can pollute water?
   (A) Canoes and sailboats used on a lake.
   (B) Fertilizers and pesticides.
   (C) Snow from the mountains.

8. People can conserve water by:
   (A) Using only the amount of water they really need.
   (B) Taking long showers.
   (C) Watering the lawn every day in hot weather.

9. What can a student or class do to show they care about the water in their community?
   (A) Use water wisely at home.
   (B) Clean-up the trash from a local stream or creek.
   (C) Recycle and dispose of household items properly.
   (D) All of the above.

10. The Bureau of Reclamation is a government agency that manages Lake Berryessa:
   (A) To store and provide water to communities and farms.
   (B) For recreation.
   (C) For wildlife habitat.
   (D) All of the above.

Match the correct word with its definition.

A. Precipitation C. Evaporation E. Reservoir
B. Condensation D. Ecosystem

___ 11. A lake artificially created by damming a stream or river.
___ 12. to change water from a liquid to a vapor.
___ 13. any form of liquid water that falls from clouds; rain, snow, hail or mist.
___ 14. A community of interconnected living and non-living things.
___ 15. when water changes from a vapor to a liquid.

Answer the following questions by marking either (T) true or (F) false.

___ 16. Canals and aqueducts are systems that deliver water to where people live.
___ 17. Flood control is one reason why dams are built.
___ 18. Hydroelectric power is generated by the wind.
___ 19. Most of California's water supply system is used by farmers to grow food.
___ 20. A typical U.S. household uses about 100 gallons of water per day per person.
___ 21. Polluted groundwater can easily be cleaned-up.
___ 22. You can conserve water by turning off the water faucet when brushing your teeth.

Pre-Site Activity

Drop in the Bucket

(Activity part of the "Kids and Creek" program of the Aquatic Outreach Institute and "Project WET" Curriculum and Activity Guide)

Summary
Students will learn through demonstration and discussion the limited amount of freshwater available on earth.

Time: 15 minutes
Setting: Classroom
Materials: 1 one liter (1000ml) graduated cylinder, 1 100ml graduated cylinder, 1 10ml graduated cylinder, eyedropper, globe or map of the earth, a container of table salt, ice (optional), metal bucket and water.
Goals and Objectives: IA
California Curriculum Standards: Science 3a and 3d. Math (number sense) 1.0, 1.2, and 2.4.

Vocabulary: Water

Background: The oceans cover approximately 71% of the Earth's surface and contain nearly all, over 97%, of its water. Freshwater resources account for less than 3% of the total water on Earth.

Earth's Total Water Supply

97.2%	Oceans (salt water)
2.8%	Fresh water
100.0%	**Total Water on Earth**

Earth's Total Fresh Water Supply

2.38%	Icecaps and glaciers
0.39%	Groundwater
0.029%	Surface water (lakes, rivers, etc.)
0.001%	Air and soil
2.8%	**Total Fresh Water**

The amount of good, clean and accessible freshwater actually available to people is a fraction of 1%.

Activity

1. Study a globe or map of the Earth, and have the students guess how much of the Earth's surface is covered in water. Record the guesses on a board (71% of the Earth's surface is covered in water).
2. Use one liter (1000 ml) of water to represent all the water on Earth. Have the students guess how much of the water is fresh.
3. Pour 30 ml of the water into a 100-ml graduated cylinder. This represents all the freshwater on earth (less than 3%). Put salt into the remaining 970 ml to simulate water found in oceans. Can people drink this water to survive?
4. Look at the cylinder of freshwater. Ask the students if all this freshwater is available for living things to use.
5. Ask the students what they would find at the North and South Pole. Almost 80% of the Earth's fresh water is frozen in ice caps, glaciers and icebergs. Pour 6 ml of freshwater into a 10-ml cylinder. For dramatic effect, place the remaining water (24 ml) into a bucket of ice or nearby freezer. Frozen water is not available for living things to use, so this cylinder should be set aside.
6. With the 6 ml of water remaining, use an eyedropper to remove one drop. Put the eyedropper aside for a moment. Tell the students the water remaining in the 10 ml cylinder is unavailable for human use. It represents atmospheric water, unreachable groundwater or water otherwise too polluted to consume.
7. The remaining one drop of water in the eyedropper represents the readily available freshwater supply on Earth (0.003% of the total). Take this single drop of water and release it into a metal bucket. Make sure the students are very quiet so they can hear the sound of the drop hitting the bottom of the bucket. Again this single, precious drop of water is all people have.

Discussion Points

- Are the students surprised by the amount of freshwater that is readily available?
- How important is it to care for and monitor our freshwater supply?
- How can freshwater supplies become polluted and unavailable for use?
- How can we conserve freshwater supplies?

Pre-Site Activity

Sponge Relay

Summary
Students will recreate the water cycle by demonstrating the process of evaporation, condensation, precipitation and run-off.

Time: 20 minutes
Setting: School yard or outdoors
Materials: 5 plastic buckets, 5 sponges, 5 cups (6 or 8oz) and water to fill the buckets.
Goals and Objectives: I B
California Curriculum Standards: Science 3a, 3b, and 3c. (Review of 4th grade science standard 3a).

Vocabulary: water (hydrologic) cycle, evaporation, condensation, precipitation, transpiration, ground water, and runoff.

Background: The water (hydrologic) cycle is the process by which water moves between the oceans and land. In the oceans, water changes from a liquid to a vapor with the application of solar energy (evaporation). Cooling of the atmosphere returns water vapor to a liquid or solid state (condensation). Cloud formation occurs when water vapor condenses into tiny water droplets or ice crystals. Once the droplets/crystals combine and grow heavy they fall as rain, sleet, hail, or snow (precipitation). The water reaching the land may runoff as streams and rivers, or may go into the ground to travel within the rocks as groundwater. Water returning to the ocean helps complete the water cycle. The direct transfer of water from plant leaves into the atmosphere is also an important part of the cycle (transpiration).

Activity

1. Break the classroom into three teams. Create three standing lines of students.
2. In front of each line, is a container of water (representing the ocean). Next to the container is a sponge. Behind the last person in line is a cup.
3. The first student in each line will take the sponge; place it in the container of water while saying **"evaporation"**.
4. The sponge is then sent over the shoulder of the first student to the second student in line. The second student then sends the sponge, under his or her arm, to the third student in line. The third student sends it to the fourth over the shoulder and so on. An under-over procession should be repeated down the line. While the sponge is being moved, each student in contact with it should be saying **"condensation"** – a cloud is moving in the sky.
5. Eventually the sponge reaches the last person in line. When this happens, the last student wrings the sponge out into a cup while saying the word **"precipitation"**. The cup represents a body of freshwater.

6. Once the sponge has been completely wrung-out, the last student walks quickly to the front of the line with it while saying the word **"transportation"** (the word "transportation" indicates the movement of water, "run-off", over land).
7. The last student is now the first student in line. He or she then repeats the cycle by soaking the sponge with more water from the container. The sponge is then passed to the second person (formerly the first).
8. Repeat the water cycle as described with the last person always moving to the front of the line.
9. The object of the activity is to be the first team to fill their cup with sponge water.

General Rules

- Students must repeat the terminology as the sponge moves through the cycle. For example when the sponge is being wrung into the cup the student doing it must say **"precipitation"**. If they don't, their team will have a penalty delay of ten seconds (meaning all action for that team will stop for ten seconds). If someone in line forgets to say **"condensation"**, the sponge will be brought immediately back to the front of the line.
- Another rule to remember is that students in line must alternate passing the sponge to each other either over or under the shoulder. Failure to do this will bring the sponge back to the front of the line.
- For this activity to be successful and a good learning experience, teachers need to be observant and sticklers for the rules. If this doesn't happen, the activity becomes too chaotic. The process (water cycle) not the final product of water in the cup should be emphasized.

Discussion Points

- If most of the rainwater comes from evaporated ocean water, why isn't rain water salty? *(The salt is a solid and does not evaporate)*
- If the salt stays behind when ocean water evaporates, why doesn't the ocean become increasingly saltier? Mention in the case of some saltwater lakes this is actually happening. The Salton Sea in Southern California is a good example of what happens to a body of water without a significant inflow of freshwater.
- The release of water vapor into the atmosphere through thousands of small holes in the leaves of plants is called what? A big oak tree can transpire 150,000 liters of water a year.
- Name some different types of precipitation? During the winter, what sort of precipitation might you expect in the mountains? How about during a thunderstorm?
- When precipitation reaches the land or earth, where does it go? Does water go underground? Do some people receive their drinking water from wells?
- How does water travel over the surface of the land? Do people capture the surface flow of water in any way?
- Where does gravity eventually like to take a traveling drop of water that is flowing on the land?

Extensions

1. Working either individually or in groups of two or three, have the students create a water cycle poster, drawing both illustrations and writing corresponding terminology.
2. Have the class make cards with pictures and words to illustrate different parts of the water cycle. As a class exercise, have the students stand-up and order the cards, in such a way, to recreate the water cycle. Try changing the order of the cards. Discuss what sort of ordering worked and what did not.

Pre-Site Activity

Watershed Wonders

Summary
Students will identify the prominent natural and human-made features found within a watershed.

Time: 20 minutes
Setting: Classroom
Materials: "Napa County Watershed Map", "Watershed Wonders Activity Sheet, crayons (blue, green, black, red, and brown), and a pencil.
Goals and Objectives: ID
California Curriculum Standards: Science 3e (Review of 4th grade science standards 3a, 5a, and 5b)

Vocabulary: watershed, tributary, aquifer, precipitation, and ground water.

Background: A watershed is the entire land area where all of the water above and below the ground drains to a common channel or body of water. It includes creek systems, flood plains, ditches, storm drains, lakes, ponds, mountain slopes, groundwater aquifers; all the areas (both natural and human-made) in which water travels to reach a particular destination.

Watersheds can be small, such as an acre of land draining into a pond, or they can be very large, covering hundreds of square miles and including many creeks and rivers. It is important to remember that small watersheds are the component pieces of larger ones. In this sense; because the world's oceans are connected, the earth itself can be thought of as a single global watershed.

Watersheds filter, absorb, store, release and transport water; enabling plants, animal life and entire ecosystems to survive and function. People are dependent on watersheds; building homes on them, tapping groundwater supplies, using flood plains to graze livestock and diverting creeks to irrigate farms. Understanding the role of watersheds in the environment is essential to better protect and manage water resources.

Activity

Preparation

1. Photocopy the **"Watershed Wonders Activity Sheet"** and **"Napa County Watershed Map"**, for each student.
2. Make sure each student has a pencil and a set of color crayons to work with – blue, green, black, red and brown.

Part I

1. Pose this question to the students: *Have you ever stood on the shore of a river and wondered – where did all the water come from and where is it going? Today we're going to try and figure this all out together.*
2. Ask the students for the definition of a watershed and solicit some possible answers.
    - A watershed is an area of land that drains surface and ground water into a common body of water like a river, creek, lake or bay.
    - A person can think of a watershed as all the land that "sheds" water onto lower areas of land. Gravity takes water from a high place to a low place. A mountain slope is a watershed, "shedding" water off the slope into a creek.
    - **Demonstration:** Bring your hands and fingers together. The knuckles of your hands have made a mountain ridgeline. If water hits the top of your right hand it flows down your right arm. If water hits the top of your left hand it flows down your left arm. You have just created two watersheds.
3. A watershed has boundaries. For example, a mountain with four slopes might have four watersheds. Each one of these watersheds would drain or "shed" water from a separate area on the mountain into a particular creek. If all four of these creeks join together to form a river, the entire mountain becomes one large watershed. The four creeks represent the tributaries of the river. Knowing this, can anyone define what a tributary is?
    - **Analogy:** All the students are drops of water and the classroom is the watershed. When the students leave the classroom and go outside, they meet other students/waterdrops from other classrooms/watersheds. The entire school is one "big" watershed made up of individual "classroom size" watersheds. Each classroom of waterdrops is one tributary (creek) for the school (river).
4. A watershed connects all life; the plants, animals and people that live on it, as well as those non-living thing like rocks and soil.
5. Everyone lives in a watershed which means we are all a part of one. Every town and city is located in a watershed, not just a cabin on the side of a mountain.
    - **Question:** Do you think all the land in the world is part of one "huge" watershed?

Part II

1. Pass out activity sheet, map and crayons. Have the students follow the instructions and answer the questions as laid out in the activity sheet.
2. Things to remember:
    - The map legend has symbols which will help you do this activity.
    - The **"Napa County Watershed Map"** is separated into three "big" watersheds. You will finish the boundary between the Napa River and the Putah Creek Watersheds. Note: The boundaries for each one of these watersheds extend beyond the Napa County line.
    - Do you remember what a tributary is?

Discussion Points

- Besides creeks, rivers and mountains, what other sorts of natural features are found in a watershed? Let's make a list together *(valleys, plains, hills, lakes, ponds, marshes, forests, etc)*.
- Does all the water in a watershed stay on top of the ground? *A watershed absorbs and stores rainwater or precipitation in the soil and in groundwater aquifers.*
- What is an aquifer? *An aquifer is an underground rock or sand area where water travels.* When groundwater comes to the surface, what do we call that? *A spring.*
- How does spring water reach the ocean? *Example: spring to creek to river to lake to river to wetland to ocean.*
- Did anyone answer the bonus question on the activity sheet – The Napa River flows into which bay? Look at a map of the bay area to find out. *Answer: San Pablo Bay which is a part of San Francisco Bay.*
- Besides houses, what other kinds of human features are found in a watershed? *Example: farms, cattle ranches, streets, roads, factories, storm drains, canals, etc.*
- What types of material does water pick up as it moves through the watershed? Where does the material come from and where do you think it will end up?

Extensions

1. Since we all live in a watershed, everything we do in some way can affect it. As a class, make a list of ways in which people affect the watershed and the water resources in your community.
2. Photocopy a topographical map of your area. Examine the natural features of the land and the contour lines. As a class or individually, outline with a marker various watershed boundaries. Look closely at the elevation, the contour lines and where the streams begin. More than one watershed may be represented in your community, each a part of a larger drainage system. The following points to remember will help when reading a topographic map:

- Contour lines connect points of equal elevation.
- The difference in elevation between two consecutive contour lines is known as a contour interval.
- Where contour lines are close together, the slope of the ground is steep.
- Where lines are far apart the slope of the ground is gentle.
- Wherever contour lines cross a stream, they always bend upstream.
- Tops of hills and mountains can be identified by a closed loop at the end of an increasingly tighter series of contours.

3. Have the students create and illustrate their own watershed. Include both natural and human features. Discuss how a community might be laid-out. For example, where do the homes and farms go – think about location!

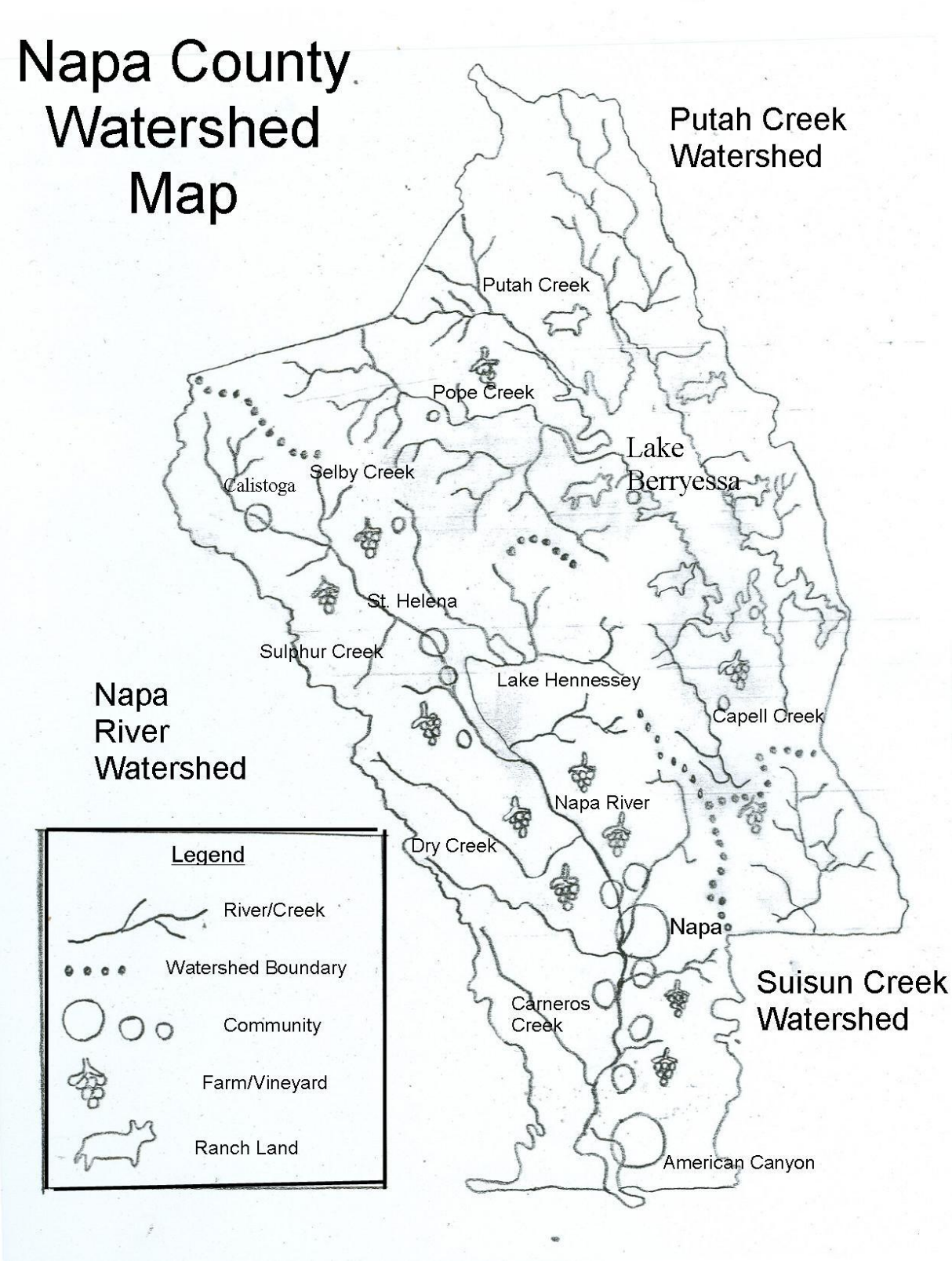
Watershed Wonders Activity Sheet

Napa County Watershed Map (Instructions)

1. Use blue to color all the rivers, creeks and lakes on the map.
2. Use black to finish the boundary between the Napa River and Putah Creek Watersheds. Think carefully where the dotted boundary line should go.
3. Use green or purple to color the farm/vineyard – places where you see grape bunches.
4. Use red to color the main areas where people live – places where you see circles.
5. Use brown to color the ranch land - places where you see cows.

Look at the map and answer the following questions.

1. Name two creeks or tributaries of the Napa River? _____ _____
2. Capell Creek is located in which watershed? _____
3. A water drop flowing off a mountain into Pope Creek will enter which lake? _____
4. Do you think a valley or a mountain ridgeline separates the Putah Creek and Napa River watersheds? _____
5. Which watershed do you think has the most people living in it? _____
6. Around Lake Berryessa are there more ranches or farms? _____
7. Which watershed do you think has more paved streets? _____
8. Most people in Napa County live near what river? _____
9. Bonus question: In the Napa River Watershed, what crop or agricultural product do people grow the most of? _____
10. Bonus question: The Napa River flows into which bay? Hint: Look at a map of the Bay Area. _____


Napa County Watershed Map
Putah Creek Watershed
Putah Creek
Pope Creek
Lake Berryessa
Selby Creek
Calistoga
St. Helena
Sulphur Creek
Lake Hennessey
Capell Creek
Napa River Watershed
Napa River
Dry Creek
Napa
Suisun Creek Watershed
Carneros Creek
American Canyon
Legend
River/Creek
Watershed Boundary
Community
Farm/Vineyard
Ranch Land

On-site Activity

A Thirsty World

Summary
Students will recognize water as a resource that needs to be equitably managed.

Time: 5 to 10 minutes
Setting: Lake Berryessa
Materials: 5 clear, plastic water pitchers and a ready supply of Dixie cups.
Goals and Objectives: IA and IIIB
California Curriculum Standards: Science 3d

Vocabulary: Resource

Background: Water is arguably the planets most valuable resource – every living thing needs it. Yet, the supply of water on the planet is not equally distributed. In California water demands often exceed the water supply, making the fair distribution and management of water resources very important.

Activity

1. Place 3 to 5 water pitchers on a table along with a supply of Dixie cups.
2. Divide the class into Group A and Group B (the class will have already been divided for the day).
3. Allow Group A to go to the water table first. Encourage them to drink or use as much water as they wish (they can wash their hands or cool off with it).
4. After about a minute, have Group A move aside so Group B can go to the water table.

Discussion Points

- Ask both groups if they received enough water.
- As a member of Group B, do you think Group A took too much water? Do you feel short-changed?
- What could have been done to make sure everyone received their fair share of water?
- Do you think people have arguments or disputes about water outside the classroom? In dry places, like most of California, water needs to be managed carefully to make sure it is fairly distributed.

Extensions: Complete Post-Site Activities *Community Forum* and *Wise Water Use.*

On-Site Activity

Lake Detectives

Summary
Students will examine the water quality of the lake by collecting and identifying aquatic invertebrates.

Time: 45 minutes
Setting: Lake Berryessa
Materials: **"**Aquatic Invertebrate Study Sheet", pencils, magnifying (bug) boxes, dissecting scope, small plastic buckets (white color), clear plastic containers to hold specimens, eye droppers, large droppers (basting utensil) fine mesh nets (i.e. nylon), "Aquatic Invertebrate Pollution Sensitivity Chart" , and "Aquatic Invertebrate Identification Chart".
Goals and Objectives: IIA, IIB, IIC and IIIA
California Curriculum Standards: Science 6a, 6c, 6f and 6g. Math (Mathematical reasoning) 1.1 (Review of 4th grade science standards 3a and 3b)

Vocabulary: invertebrate, aquatic, larvae, sensitive, tolerant, pollution, indicator species, water quality, scientist and biodiversity.

Background
Clean water is essential for all life to exist. The processes of life from the cellular level to that of the ecosystem are dependent on an adequate quality of water. People directly affect water quality, sometimes degrading an invaluable natural resource by making it less clean and usable. These effects are the results of pollution, land use within a watershed and from activities on the water surface itself. Disturbances brought on by increase sedimentation and the addition of foreign materials changes water chemistry, impacting such things clarity, temperature, PH and biological diversity. To understand change in water quality, certain environmental conditions or variables can be examined. Additional background information on water quality variables that may be tested is located in the appendices of this program.

Freshwater Invertebrates: Aquatic invertebrates are good indicators of water quality because:

- They are directly affected by the physical, chemical, and biological conditions of the water.
- They can't escape pollution and show the effects of short and long-term pollution events.
- They are a critical part of the aquatic food web.
- They are relatively easy to sample and identify.

The main reason for monitoring aquatic invertebrates is that some species are more sensitive to water pollution than others. These species are often referred to as "indicator species". If a body of water has an abundance of pollution tolerant species, and is missing more sensitive ones, it can be an indication of a pollution problem.

Looking at the diversity and relative abundance of particular invertebrates will indicate if water is being impaired but not what might be impairing it. To get a complete picture of water quality, other variables or factors need to be examined. For example, low dissolved oxygen levels are a reason why many invertebrates cannot survive in polluted or stagnant water. This variable can be the result of excessive algae die-off and decomposition. The abundance of algae, in turn, might have been triggered by phosphates and nitrates entering the system through erosion and the improper discharge of fertilizers.

Activity

Introduction: The students have come to Lake Berryessa, as scientist, to examine the water quality of the lake. The information they gather will help the park to learn about its resource and to make good resource management decisions. Ask the students:

- What is a good resource management decision? (For example; keeping pollution out of the water so fish can survive).
- To name things that can be examined to determine water quality? (For example, how the water looks, how it smells, its temperature and what might be living in it).

Tell the students that the things they named are good ways to examine water quality. Today, we will be looking at what lives in the lake as a way to study water quality.

Before students begin their observations, the ranger will:

- Emphasize that the students are now scientists.
- Ask the students what a scientist does.
- Discuss the importance of observation when doing science.

Aquatic Invertebrate Study

Ask the students these questions:

- Does anyone know what an invertebrate is? *(Answer: an animal without a backbone. These are critters that usually have the hard parts of their body on the outside "exoskeleton" and the soft parts inside. People have their hard parts "bones" on the inside.)*
- Can somebody give an example of an invertebrate? *(Remember: fish and frogs are vertebrates – they have backbones)*

Invertebrates that live in the water for at least part of their lives are known as aquatic invertebrates *(aqua is another word for water*). Some aquatic invertebrates live only in the water when they are babies or larvae. Others will spend both their adulthood and larval stages in the water.

Aquatic invertebrates are good indicators of water quality. Many species die or disappear when the water becomes polluted.

- What might happen if the aquatic invertebrates were to disappear from Lake Berryessa?
- Would the food chain be affected – think fish?

Today, we are going to collect as many different invertebrate species as we can from Lake Berryessa. To do this, different collecting tools are available for you to use. Suggestions for collecting aquatic invertebrates:

1. Scoop water out of the lake with a plastic bucket or other container.
2. Find water that has natural debris in it. For example water with aquatic plants or bits of twigs and leaves. Some mud is ok in your bucket but too much will make it difficult to see anything.
3. Use scoopers, small nets and eye droppers to gather the invertebrates from the bucket. Since most of the invertebrates you find will be very tiny, the eye droppers will work best.
4. Put the invertebrates you gather into magnifier boxes for a better look. Make sure water is in these boxes so the invertebrates don't dry-out and die.
5. Use the **Aquatic Invertebrate Identification Chart** to identify the invertebrate you have found.
6. Check its name off on the **Aquatic Invertebrate Checklist** on the study sheet you have been given.
7. Continue to check-off each new invertebrate you find.
8. Show other people what you have found.
9. Work as a team to identify the invertebrates. Remember you're a scientist and scientists like to help each other out.

Again, some aquatic invertebrates are more sensitive to water pollution than others. On the **Aquatic Invertebrate Identification Chart**, the invertebrates have been separated into three sensitivity categories. The three categories are:

- Sensitive - Do NOT Tolerate Pollution
- Moderately Tolerant - Tolerate Some Pollution
- Tolerant - Tolerate Pollution

10. Write the names of the aquatic invertebrates marked on your **Checklist** into the three sensitivity categories. Use the **Aquatic Invertebrate Identification Chart** to determine which category each belongs in.
11. Tally the total number of species you found from each category**.** *(Can be done in the classroom using the **Aquatic Invertebrate Pollution Sensitivity Chart** included with this activity).*
12. Complete the two questions in the **Aquatic Invertebrate Study Sheet** *(can be finished in the classroom)*.
13. Return invertebrate specimens to the lake. Put all collecting materials back where they belong.

Discussion Points:

- Based on your observations and the invertebrates you collected what can you say about the health of Lake Berryessa?
- Is there anything that you discovered that was surprising?
- Which invertebrates were most abundant? How many different species did you find? Do you think weather or time of year might have had an influence on the invertebrates you were able to find?
- Why are invertebrates important to the lake?
- Who should be responsible for keeping water clean?

Extensions:

1. Complete the Post-Site Activity *Scientific Method*
2. As a class, draw a poster of the Lake Berryessa invertebrates. Include their names and any interesting facts you discovered about them (see if your school library has some books on the subject, or use the internet to research aquatic invertebrates).

Student Name _____

Aquatic Invertebrate Study Sheet

Aquatic Invertebrates are organisms without backbones. They live in the water, often hiding in the mud, under rocks and on submerged logs and vegetation. Sometimes water invertebrates are very small and difficult to find.

See how many water invertebrates you can find in Lake Berryessa. Use the equipment provided to collect as many as you see. Put your invertebrates into buckets and magnifier boxes for other students to look at. Try to identify all the different kinds of species you find (use the **Aquatic Invertebrate Identification Chart**). Check the boxes next to the invertebrates found on the **Aquatic Invertebrate Checklist** below. Remember to look at the invertebrate before you check it off – their cool!

Aquatic Invertebrate Checklist

□ Dragonfly Nymph	□ Caddisfly Larvae	□ Mayfly Nymph
□ Hydra	□ Dobsonfly Larvae	□ Daphania (Water Flea)
□ Copepod	□ Scud (Amphipod)	□ Water Mite
□ Water Scorpion	□ Water Strider	□ Damselfly Larvae
□ Wirligig Beetle	□ Backswimmer	□ Diving Beetle
□ Crayfish	□ Water Scavenger Beetle	□ Seed Shrimp
□ Water Boatman	□ Giant Water Bug	□ Flatworm (Planaria)
□ Leeches	□ Snails	□ Midge Fly Larvae
□ Mosquito Larvae	□ Clams	□ Aquatic Worms

Aquatic invertebrates are good indicators of water quality. Some easily die when water becomes polluted. Using your **Aquatic Invertebrate Checklist** and the **Aquatic Invertebrate Identification Chart** (provided with this activity), record all the species you and your classmates have found by separating them into three categories. Tally the total number of species from each category on the back of this sheet.

Species that are:

Sensitive	Somewhat Tolerant	Tolerant
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

_____	_____	_____
_____	_____	_____
_____	_____	_____
Total number_____	Total number_____	Total number_____

What kind of aquatic invertebrates did you find the most of?

_____

_____

What does the presence or absence of certain aquatic invertebrates tell you about the health of Lake Berryessa?

_____

_____

Draw a picture of one aquatic invertebrate you have seen. Write down its official name as well as one you think it should have – be creative.

Aquatic Invertebrate
Pollution Sensitivity Chart

Sensitive	Somewhat Tolerant	Tolerant
Caddisfly Larvae	Dragonfly Nymph	Midge Fly Larvae
Dobsonfly Larvae	Hydra	Flatworm (planaria)
Mayfly Nymph	Copepod	Leeches
Water Mite	Water Scorpion	Aquatic worms
	Whirligig Beetle	Clams
* Stonefly Nymph	Water Boatman	Snails
* Alderfly Larvae	Scud (Amphipod)	Mosquito Larvae
* Water Penny	Water Strider	
* Riffle Beetle	Backswimmer	* Blackfly larvae
	Giant Water Bug	
	Seed Shrimp	
	Daphnia (water flea)	
	Damselfly Larvae	
	Diving Beetle	
	Water Scavenger Beetle	
	Crayfish	

*** These aquatic invertebrates have not been included in either the student's Aquatic Invertebrate Checklist or the Aquatic Invertebrate Identification Chart. Their excluded because they require moderate to fast flowing water, something characteristic of a stream environment not a lake.**

On-Site Activity

Journey of a Water Drop

Summary
Students will recreate the journey of a water drop through both a natural and human made system. Water origin, water use, water allocation and the infrastructure required to store and move water will be examined.

Time: 20 minutes
Setting: Lake Berryessa
Materials: 60 blue strips of cloth two feet in length, 30 orange cones, 2 sets of PVC pipe fastened together by a cross PVC pipe (one set painted white and the other set rusty red), 4 red flags on poles, 15 *water user* signs, 15 clothes pins and electronic buzzer (optional), and assorted play equipment.
Goals and Objectives: IA, IC, IIA, IVA and IVB
California Curriculum Standards: Science 3d and 3e

Vocabulary: reservoir, dam, canal, aqueduct, agriculture, irrigation, hydroelectric power, and Bureau of Reclamation.

Background: Water is the essential ingredient of all life, yet its distribution across the planet is far from even. Some places are extremely arid (desert) whereas other places have an abundance of precipitation (rainforest). Disparities in water availability have lead people to modify their environment, alter natural hydrologic systems in order to collect, store and transport water. In California, a network of elaborate engineering projects has allowed large cities to exist and millions of acres to be farmed (farmers receive more water in California than any other group of users). Creeks have been channeled in concrete, dams erected, reservoirs created and canals and aqueducts built in order to make water resources readily available.

Lake Berryessa is one important link in the State of California's water management system. The reservoir was created by the Bureau of Reclamation, a federal resource agency under the Department of Interior, to store water for communities, businesses and farms in Northern California. Additional benefits of the reservoir include: recreation (water sports and fishing), wildlife habitat (primarily for water fowl and migratory birds), hydroelectric power generation and flood control.

The reservoir is part of the Solano Project. The project was designed to irrigate approximately 96,000 acres of land and to furnish municipal and industrial water to the principal communities of Solano County. Putah Creek watershed is the source of water for the Solano Project. The construction of Monticello Dam, across a narrow gorge on Putah Creek, flooded Berryessa Valley creating the reservoir. Water leaving the dam reenters the creek, where much of it is diverted into a canal (Putah South Canal) as part of a county distribution system.

Activity

Preparation

Lay-out the "Journey of a Water Drop" course. Designate the following 'coned' areas.

1. Lake Berryessa. The starting point for the activity. The place where the students will sit to hear instructions.
2. Dam. Represented by two white posts fastened to a white cross beam (made with PVC piping). Students will duck beneath the cross beam as they begin their journey down Putah Creek. Optional: Have a buzzer with a button (an electrical sound device) at the dam. As the student pass through the dam, they'll push the button illustrating the generation of hydroelectric power.
3. Putah Creek. After leaving the dam, the first area the students will pass through is Putah Creek. Create the boundaries of a fifty foot long by seven foot wide creek with cones.
4. Diversion Zone. The next area students pass through is the diversion zone, a coned corridor continuous with Putah Creek. Create the boundaries of a one hundred foot long by seven foot wide zone with cones. Red flags on poles coming out of the first two cones and the last two cones distinguish the diversion zone.
5. Delta/San Francisco Bay. The final area students pass through is the delta and San Francisco Bay. This area is continuous with the Diversion Zone. Create the boundaries of a twenty-five foot long by twenty-five foot wide Delta/Bay with cones.
6. Golden Gate Bridge. Students end the "Journey of the Water Drop" by passing beneath the Golden Gate Bridge into the Pacific Ocean. The bridge is represented by two red arching posts fastened to a red cross beam at the end of the course (the final cones marking San Francisco Bay).
7. Water Cycle Circle. In addition to the course itself, set up a coned circular area about ten feet in diameter.

Part I

1. Have the students seated on the ground looking out at Lake Berryessa. Ask them if they know how the lake was made. Distinguish between a lake and a reservoir. Briefly discuss:
   - Damming of Putah Creek and the construction of Monticello Dam in 1957.
   - Flooding of the Berryessa Valley and the farming town of Monticello.
2. If a fertile farm valley was flooded to create a reservoir, there must have been a reason. Have the students' think of some reasons for the lake's existence. Lake Berryessa provides: (a) water storage for Northern California communities, businesses and agriculture, (b) flood control, (c) water recreation, (d) wildlife habitat, (e) hydroelectric power, (f) Picnic, hiking and camping areas, (g) education opportunities – *the reason we are all here today*!
3. Where does the water go once it leaves Lake Berryessa? To find out, take the journey of a water drop.

Part II

1. Tell the students that through this activity, they will demonstrate where water goes once it leaves Lake Berryessa. To do this,most of the students will need to become water drops on a journey.
2. The journey they make will be along a course that has already been laid-out (see **preparation** section of activity).

3. Two groups of participants are represented in the activity; the *water drops* and the *water users*. 90% of the students become *water drops*. The remaining students as well as any adults become *water users*.
4. Give a blue strip of cloth to each *water drop*. Have the *water drops* tuck the strip into their back pocket or in between their shirt and pants. The cloth strips should hang loosely trailing away from the body. Give each *water user* a sign identifying who they are; farmer, factory owner, town resident etc. The signs are attached to the front of the *water user's* shirt by a clothes pin.
5. Have the students stand-up. Point out the course the *water drops* will take on their journey. The **first area** is Lake Berryessa, presently where their standing. The **second area** is Putah Creek. To move from the lake to the creek the students will pass beneath a beam representing Monticello Dam. Once in Putah Creek the *water drops* casually flow, providing wildlife habitat and a place for people to swim and fish. Have the water drops do a little dance or shuffle as they slowly pass along the creek. The dance can be accompanied by a chant: *fishing, boating, swimming, yeah!* ,*fishing, boating, swimming, yeah! , etc*. The **third area** is the diversion zone. It begins when the red flags appear. The diversion zone is where water in Putah Creek is diverted, taken out of the creek to be used by people. The *water users* will be in this area to grab water drops. *Water drops* must move quickly through the diversion zone to avoid having their water tails (strips of cloth) pulled-off. Those students who avoid having their tails pulled-off move from the diversion zone into the next area. The **fourth area** represents the delta and San Francisco Bay. Here, the *water drops* can slow down, catch their breath and walk. Water entering the delta and bay renews wetland habitat, bringing needed fresh water to plants and animals, including a little fish found nowhere else in the world called the delta smelt. Have the *water drops* chant; *smelt, smelt, smelt, smelt, smelt* as they pass through this area. The course ends when the *water drops* leave the bay and go beneath the Golden Gate Bridge into the Pacific Ocean.
6. Show the students the **water cycle circle**. The circle is separate from the course but still a part of the journey. *Water drops* that loose their tails in the diversion zone can pick up a new one here. New *water drops* are created by the water cycle process. However, before a *water drop* can leave the circle with a new tail, the water cycle cheer must be shouted – *evaporation, condensation,* and *precipitation.* The *water drops* that safely make it to the Pacific Ocean also enter the water cycle circle before starting the course again (they must go from salt water back to fresh water). These drops will not need a new tail but still must do the water cycle cheer.

Part III

1. It is easy to create different rounds or scenarios for this activity, refine it in such a way that other important ideas related to water use are brought forward. Two important concepts that can be expanded on are**;** water demand over time and water allocation.
2. The demand for water in California increases as the State's population grows. To illustrate this, increase the number of *water users* in the second round, create more dangers or obstacles the *water drops* must negotiate on their journey to the sea. A third round can be played where still more *water users* are added to the activity. Each one of these rounds can represent a different time period. For example, the first round can depict water demand during the gold rush and when California gained Statehood (1849 and 1850 respectively). The second round might reflect the time period of the 1930's and

1940's when immigration into the State was significant. A final round could represent California's present population (around 35 million).

3. Water is allocated to different "user groups". Roughly 80% of the State's developed water supply is used to irrigate agricultural land. The remaining water is for municipal and industrial use. Play a second round of the activity by dramatically increasing the number of *water users* that are farmers. Skew the ratio between farmers, town residents and factory owners to better reflect how water is allocated.
4. After two or three rounds, sit the students down and discuss what was learned.

Discussion Points

- Where does the water from Lake Berryessa come from? What is a watershed? Our watershed is called the Putah Creek Watershed. Before the dam was built, all the various streams in the area drained into Putah Creek. Now most of these streams as well as Putah Creek go directly into the lake.
- Besides recreation, why are reservoirs like Lake Berryessa an important community resource?
- How is a reservoir created? What is hydroelectric power?
- Why were most of the *water users* in the activity farmers? Four-fifth of California's developed water supply goes to agriculture, what percent is this?
- What sort of crops do we grow in California with our water? Water from Lake Berryessa is used to grow corn, wheat, sugar beets, tomatoes, fruits, nuts, and to irrigate pasture. Growing a day's worth of food for one person takes about 1700 gallons of water – enough water to fill-up 60 bath tubs.
- Does anyone know California's biggest water using crop? (Alfalfa) Does anyone here eat alfalfa? If no is the answer, why does alfalfa cover more land and use more water than any other crop in the State? Answer: Alfalfa is harvested mostly for hay to feed livestock, especially dairy cows. If you like milk in your cereal, you should like alfalfa and the water necessary to grow it.
- How does water travel from Lake Berryessa to a person's home? Name the parts of a water delivery system? Think of the aqueducts, canals and pipelines necessary to transfer water from a reservoir to a community. Do you think California would receive all the water it needs without a water delivery system? Why can so many people live in dry places like Los Angeles and San Diego?
- Why does the value of water increase as the population grows? What will need to be done to ensure an adequate water supply for California's future? Think conservation.
- As the human population grows in the State, will there be enough water for both wildlife (including the Delta Smelt) and people? Is there a way to share? Think conservation.

Extensions:

1. Write a creative story about the journey of a water droplet. Include in the story both the natural and human-made pathways in which water travels to reach a sink or bath tub. Give the water droplet a personality; what sort of obstacles does it encounter on its journey? Add illustrations to the story. Make the story more relevant to the students by having them research how water reaches their own homes.
2. Have the class list groups of water users in their community. Explain to the students water is a limited resource that needs to be allocated and shared. Working in small groups, tell the students they must determine who has the right to use water first, second, third, etc in the community. As a class, discuss how it was determined which water users were most deserving. Have the students think about the consequences of their choices. Is there a group least deserving of water and if so what might happen if their water supply was limited? For example, if industry had their water supply reduced the production of what they make might also be reduced. This could result in laying-off workers, which affect families. Likewise, farms use large quantities of water, yet they supply people with large quantities of inexpensive food. Remind the students that the parts of a community are interconnected and dependent on one another. Problems associated with water availability and allocation can be addressed when communities work together to both conserve and use water more efficiently. *(This extension originates from the Project Wet activity "common water")*

On-Site Activity

Take A Walk On The "Water-Side"

Summary
Students will participate in an interpretive walk to learn the importance and relationship of water to the entire ecosystem.

Time: 45 minutes
Setting: Smittle Trail at Lake Berryessa
Materials: "Each one teaches one" water education cards
Goals and Objectives: IB, IC and IIC
California Curriculum Standards: Science 3d, 3e and 6a. Reading 1.2. (Review of 4th grade Science standards 3a, 3b, 5a, and 5b).

Vocabulary: erosion, weathering, environment, ecosystem, photosynthesis, adaptation, organism, transpiration, reservoir, and evaporation.

Background: Water has made the planet; it has shaped a non-living world while giving life to a living one. Rain, ice, snow, oceans, rivers, and lakes have deposited and stripped away landforms, helping to create the earth's physical features. In other words, water is an agent that both builds mountains and tears them down. Water is also the substance of life. Since three-quarters of the planet is covered with water, many organisms make their home in a water environment. Other organisms live on land, including deserts, but need water in order to survive. To survive in different ecosystems, plants, animals and other living things have special features or adaptations that help them to conserve and obtain water. Exploring an ecosystem is an exploration of water itself.

Activity:
Everyone can be a teacher. For this walk, each student will have the opportunity to share a bit of information about the local ecosystem with his or her fellow classmates. Students will be positioned along the trail to point out and ask a question about the areas natural features. A water education card will help provide information to the student-teacher about what is being examined.

The walk is designed as an "each one teaches one". It begins with the ranger positioning the first student-teacher along the trail with a water education card. In effect, the student-teacher becomes a station on an interpretive nature trail. Subsequent students then, one at a time, walk up and visit the station, receiving information directly from the student-teacher. Each time a student passes a station that student, with guidance from the ranger, becomes the next student-teacher on the trail. Essentially students leapfrog each other along the trail, alternating between being the "giver" of information and the "recipient". The student-teacher stays at their station until all the students have passed it (the presents of an adult teacher or ranger at the end of the hiking column signifies to the student-teacher that it's time for them to become students again and start walking).

For this activity to work, the following points need to be considered:

- The ranger is always at the front of the line to hand-out water information cards and to position the student-teachers by the feature they will be interpreting.
- One student at a time only visits a station (student-teacher). The tendency, especially at the beginning of the hike, is for students to bunch-up. A student should stop and wait 20 or 30 feet before reaching a station if the student ahead of them on the trail is still visiting that station. The student-teacher should ensure only one person is at their station at any given time. This activity is not a race; students should walk leisurely between stations. The station visit, itself, will generally last 15 to 20 seconds. When a question is being asked at a station, a student should be given a few seconds to answer it. If the student doesn't know the answer, the student-teacher can help them out.
- Student-teachers should take on their role seriously. Students visit a station to learn, making the student-teacher's role essential. Likewise, the student must show respect to the student-teacher, patiently listening to what they have to share. **Remember:** The respect the student shows to the student-teacher is the same respect they would want when the roles are reversed.
- An adult teacher or another ranger is always the last person on the trail. There role is to assist with group management and to watch for stragglers (ideally, it is nice to have another adult hiking somewhere in the middle of the group to ensure students are following the activity instructions).

Each water education card presents a single idea or a question the student is to answer. Generally the card relates to a feature, something that is easily noticed. On other occasions, the card will express a general water-related concept. The student-teacher is there to read the card and to, when necessary, point out what the card relates to. A station visit should last no more than 30 seconds.

Discussion Points:

- Name one thing you learned along the hike today?
- Is there anything that you discovered on the hike that was surprising?
- Is there any information you heard along the hike that seemed unclear?

Extensions:

1. Find a spot on the lakeshore of Lake Berryessa. When you have found your spot, sit and write a creative paragraph or a creative poem using ONE of the following subject titles (you may also draw a picture to illustrate your writing).
   A. Lake Berryessa is inspiring and exciting.
   B. A day in the life of a water drop from Lake Berryessa.
   C. My life as an invertebrate in Lake Berryessa.
   If time at the lake doesn't allow for this activity, it can be done as a classroom assignment back at school.
2. As a class, make a list of ways plants and animal (including people) adapt to either obtain or conserve water. To make the assignment more challenging, name a particular organism then think of an adaptation it might have. An adaptation can be both a physical trait as well as a behavioral one.

On-Site Activity

Pollution Blob Tag

(A modification of Project WET "Macro-invertebrate Mayhem")

Summary
Students will recreate the affects of poor water quality on the presents and diversity of invertebrate species.

Time: 15 minutes
Materials: 25 burlap bags and 4 activity cones
Goals and Objectives: IIA, IIC, and IIIA
California Curriculum Standards: Reading 1.0 (Review of 4th grade science standards 3a and 3b).

Vocabulary: invertebrate, aquatic, biodiversity, organism, larvae and oxymoron.

Background:
Invertebrates are organisms (living things) that lack an internal skeleton. They can inhabit all kinds of aquatic (water) environments, from fast moving streams to sluggish ponds. Examples of aquatic invertebrates include mayflies, water mites, dragonflies, water fleas, crayfish, leeches and snails. These organisms may spend all or part of their lives in the water; usually their immature phases (i.e. the larval stage) are spent entirely in the water.

Aquatic Invertebrates are good indicators of water quality. Habitat stress brought on by environmental disturbances effect invertebrate population and diversity. Some invertebrates, such as mayflies, are sensitive to changes in water condition brought on by pollutants. Other aquatic organisms, for example midge fly larvae and flatworms, can tolerate water more highly contaminated. The presents, absents and relative abundance of a particular species is a clue to the health of a water system.

Fish diversity is also associated with water quality. For instance, trout and salmon need clearer water with higher oxygen levels than catfish and carp. If sedimentation becomes a problem and oxygen levels decrease, fish species tolerant of these conditions will be favored for survival. It should be noted that the "natural state" for a body of water must be understood before it can be determined whether a fish species or invertebrate should be present or not.

Bird species that feed on aquatic organism are directly dependent on water quality. If there's a decline in fish numbers, fish eating birds like eagles, ospreys and herons will be affected. Sometimes, though, the issue is not the availability of food but the quality of the food itself. Fish-eating birds are especially susceptible to poisons or contaminants that accumulate in the tissues of fish. An individual bird, eating numerous fish, magnifies the poison, making it potentially lethal or reproductively damaging. This same issue is often a concern with people eating fish contaminated with such things as mercury.

Activity

Preparation

1. Create a playing field with boundaries by using two activity cones as a starting line and two as a finishing line. The size of the playing field will depend on how many students there are. A good distance between starting and finishing line is fifty to a hundred feet.
2. Have upwards to 25 burlap bags available at the starting line.

Part I

1. Tell the students they are going to play a game that will show how changes in water quality, brought on by pollution, affect aquatic organisms.
2. Have two students volunteer to be "pollution blobs". Briefly discuss with the students what a "pollution blob" might be (e.g., sedimentation, sewage or fertilizers). In this game, "pollution blobs" move across the playing field together with locked elbows.
3. Divide the rest of the students into three groups. Each group represents an invertebrate species; caddisfly larvae, whirligig beetle and snail. The different species will each move across the playing field in a special way.

- Caddisfly larvae place both feet in the burlap bag and hop.
- Whirligig beetles spin in circles.
- Snails run. Think of the irony – running snails!

Part II

1. Assemble the three invertebrate groups at the starting line. Have the two "pollution blobs" (joined together at the elbow) somewhere in the middle of the playing field.
2. The object of the game is for the invertebrates to move across the field, to the finish line, without being tagged by a "pollution blob". The "pollution blobs" can tag an invertebrate with either one of their free hands. If an invertebrate is tagged, it must leave the playing field until the next round.
3. Begin round one. The round ends when all of the invertebrates have either been tagged or have reached the finish line of the playing field.

Part III

1. Reassemble all the students at the end of round one back to the starting line.
2. Determine which invertebrates made it to the finish line. These students will be the same invertebrates for round two.
3. Those students/invertebrates tagged by "pollution blobs" become "pollution blobs" in round two. Pairs of students must join up to become "pollution blobs." If an odd number student is left out and cannot find a partner to pair with, have them join with an existing "pollution blob" to create a three person blob (the center student in the blob will not have a free hand to catch invertebrates).
4. Before beginning round two, have the students take note of which invertebrates seem more susceptible to "pollution blobs."
5. The game can be completed after three or four rounds. Each successive round represents an increasing pollution problem. The invertebrate population and diversity decline as "pollution blobs" become more numerous. By the final round, probably only the swiftest snails (oxymoron) have survived.

Discussion Points

- Which invertebrate was most affected by polluted water? Caddisfly larvae are intolerant of the low oxygen levels that often result from pollution. By the way, caddisfly larvae also build cases out of rock and woody material to cover their body – somewhat reminiscent of the burlap bags.
- Which invertebrate was the next one most affected by pollution? Both whirligig beetle adults and larvae are predaceous; they feed on other invertebrates smaller than themselves. They can tolerate some pollution but eventually disappear if the water becomes too polluted.
- Which invertebrate seems to tolerate the most pollution? Snails, along with leeches and aquatic worms, will often increase in numbers when other, more sensitive invertebrates decline. They can sometimes overwhelm lake and river habitats. However, when pollution becomes 'really bad', not even the snails can survive.
- What is an oxymoron (e.g., swift snail, jumbo shrimp, and dry lake)?

Extensions

1. Have students study aspects of biodiversity by adding another round to the game. For example, add a round where all the invertebrates are caddisfly larvae. This round could demonstrate how a sensitive species can be quickly and entirely eliminated.
2. Create a pollution blob chart. Record how many caddisfly larvae, whirligig beetles and snails survive each round. The rounds (representing years) and the invertebrate surviving numbers can be charted on a graph.

On-Site Activity
The Water Cycle Boogie

Summary
Students will recognize the main parts of the water cycle through song.

Time: 10 minutes
Setting: Lake Berryessa or Classroom
Materials: None needed – just vocal chords
Goals and Objectives: I B
California Curriculum Standards: Science 3a, 3b, and 3c. (Review of 4th grade science standard 3a)

Vocabulary: hydrologic (water) cycle, evaporation, condensation, precipitation, transpiration, and runoff

Activity:
The *Water Cycle Boogie* is used to introduce important terminology related to the water cycle. Exaggerated hand movements and body language accompany the song. The song begins with students learning the chorus: *The water cycle boogie goes up and down* (student's squat then stand). *The water cycle boogie goes round and round* (students spin around). *Up and down* (students squat and stand again). *Round and round* (students spin around again). Following the chorus, the first verse or vocabulary word of the song is introduced - *Evaporation!* As the students shout the word *evaporation* they wiggle their fingers and thrust there arms over their heads. The second verse - *Condensation!* , requires the students to make broad sweeping movements with their arms, as if making a cloud. For the third verse – *Precipitation!* , students wiggle their fingers downward. The final verse – *Transportation!* , denotes movement of water (runoff). For this last one, students jog in place.

Be creative and come up with your own unique body motions that will remind the students of the concepts and terms. You might also increase the tempo of the song as it goes along, to increase excitement and fun. A brief description of the concept should be given each time a verse is added to the song.

Song:
The water cycle boogie goes up and down.
The water cycle boogie goes round and round.
Up and down, round and round.

Evaporation! *(First verse then repeat chorus)*
Condensation! *(Second verse then repeat chorus adding first verse)*
Precipitation! *(Third verse then repeat chorus adding first and second verse)*
Transportation! *(Fourth verse then repeat chorus adding first, second and third verse)*

Post-Site Activity

Wise Water Use

Summary
Students identify water use at home and suggest ways to practice water conservation.

Time: 30 to 60 minutes (classroom time)
Setting: Classroom and home
Materials: "Water Use Worksheet", "How Much Water Does It Take" reference sheet, "Water Conservation Suggestions" reference sheet and a pencil
Goals and Objectives: IC and IIIB
California Curriculum Standards: Science 3d and 6g. Math (number sense) 1.0, 2.4 and 2.5. Math (mathematical reasoning) 1.0, 1.1 and 1.2.

Vocabulary: conservation, direct water use, and indirect water use

Background: The United States uses over 200 billion gallons of water daily; enough water to completely drain Lake Berryessa in less than three days. Of this, the greatest amount of fresh water is used for agriculture. Lesser but still enormous quantities of water go to industry and household needs. At home, the average Californian uses between 100 and 200 gallons of water a day. That's enough water to fill at least three bathtubs!

Household water use is roughly split between indoor and outdoor needs. The toilet alone accounts for roughly a fifth or 20% of domestic water consumption. Flushing a toilet, turning on a faucet, washing clothes and watering the grass are all examples of direct water use. However, people use an even greater amount of water indirectly. For instance, it takes about 48 gallons of water to produce one 8oz glass of milk. This includes: water for cows to drink, water to grow food for the cows to eat, water to clean the milking and processing equipment, and water to generate the electricity used to run the equipment.

As the population of California grows, more water will be required both directly and indirectly to meet the needs of communities. Will there be enough water in the future to go around? One way to help ensure this is for everyone to use water wisely, starting with good water conservation practices at home.

Activity
Preparation: Photocopy the "Water Use Worksheet" for each student.

Part I (Classroom)

1. Have each student write a list of ways they use water. Compile the classes list on the blackboard.
2. If the class list does not include indirect uses of water, ask the students if they think they use water when they drink a glass of milk, ride in a car, or read a book. Explain that producing milk, cars, and the paper in a book requires water. Have students suggest other ways they indirectly use water.

3. From the class list, ask the students to guess how much water they think is needed to either do something, like flush a toilet, or to make something, like a car. Use the "How Much Water Does It Take?" reference sheet to share with the students.

Part II (Homework Assignment)

1. Pass out the "Water Use Worksheet" as a homework assignment. Have the students follow the instructions and work with family members at home to answer the questions.
2. Give the students two days to complete the worksheet.

Part III (Classroom)

1. Have students share results of their "Water Use Worksheet" with the class.
2. Record on the blackboard the number of gallons used in each student household. Determine the household average by adding all the gallons together and dividing by the number of students in the class.
3. Use student suggestions to create a list on the blackboard of ways people can conserve water at home. Include ideas from the "Water Conservation Suggestions" reference sheet.
4. Share with the students four basic ways to practice water conservation at home:
   A. Care in Use. A conscious change of attitude is the first step to saving water.
   B. Stopping leaks. Most leaks are simple to find and easy to fix.
   C. Water-saving devices. For example, install a "low flush" toilet system.
   D. Recycling water. Use water for more than one job.

Discussion Points

- Where do you use most of your water at home?
- Why is the number of gallons used in your household *less* or *greater* than the classroom average?
- Do you see any ways that you could use less water?
- What does it mean to conserve water?
- Why, as California residents, is it especially important to conserve water?
- If we use less water at home will that affect other areas, for example agriculture and the environment?
- As consumers, can we save water indirectly by what we choose to eat or the products we buy? Can you think of any examples?

Extensions

1. Have students keep a personal water use journal at home for a month. The journal should be used to track daily water use habits as well as any behavior changes made to conserve water.
2. Research a water-saving device. Report on what you learned to the class.
3. As a class, carry out a water conservation project at school or in the community.

Water Use Worksheet

Here is a chance for you to find out some information about your family's water use. Talk to other family members in order to complete the worksheet.

How many water users are in your household? _____

Directions: Complete the chart below to determine how much water you and your family use at home during a 24 hour period of time. Put a checkmark in the tally column **each** time that any of the activities are performed. Multiply the number of checkmarks by the gallons per use to determine the total gallons needed to perform that activity over a 24 hour period. Note: *The "gallons per use" is the average for that activity.*

Activity	Gallons Per Use	Tally Column	Total Gallons
brush teeth (water running)	3		
flush toilet	5		
wash hands (water running)	2		
take shower (10 minutes)	35		
take bath (tub full)	40		
drink water	1/8		
wash dishes by hand	30		
dishwasher (full cycle)	15		
clothes washing machine	30		
meal preparation	5		
watering outside (by hand)	10 gallons a minute		
other	you estimate		

Number Of Gallons Used In The Household Over A 24 Hour Period Of Time _____
(To calculate this, add the total gallons for each activity together)

Number Of Gallons Used In The Household Per Person _____
(Divide number of people in the household by the gallons used over a 24 hour period)

Write down some ways you think you and your family can save or conserve water at home. Refer to the activity list in the chart above for ideas. _____
_____
_____
_____

Indirect Water Use
Determine how much water it takes to produce a cheeseburger by adding the number of gallons for each item together. 1. Ground beef (4 ounces) – 615 gallons. 2. Bun, top and bottom – 22 gallons. 3. Tomato slice – 3 gallons. 4. Lettuce – 1 gallon. 5. Cheese – 56 gallons. **Total Number Of Gallons Needed _____**

How Much Water Does It Take?

Direct Water Use

- Flushing the toilet (once): 4 to 7 gallons.
- Brushing your teeth: 2 to 4 gallons.
- Washing your hands and face: 1 to 4 gallons.
- Taking a bath: 30 to 40 gallons.
- Taking a shower: about 5 gallons per minute.
- Dishwasher (one load): 9 to 12 gallons
- Washing dishes by hand: Upwards to 20 gallons.
- Washing clothes (one load): 35 to 50 gallons.
- Washing the car: Average 50 gallons.
- Watering the lawn and yard: Average 180 gallons.
- Cooking a meal: 5 to 10 gallons.
- Drinking a glass of water: 1/8 of a gallon.

Indirect Water Use (the amount of water it takes to produce something)

- Lettuce (one cup): 3 gallons.
- Catsup (one ounce): 3 gallons.
- Sugar (one tablespoon): 7 gallons.
- Whole wheat bread (one slice): 7 gallons.
- White bread (one slice): 11 gallons.
- Broccoli (half cup): 11 gallons.
- Orange (one medium size): 14 gallons.
- Soda (one can): 16.5 gallons.
- Brown rice (half cup): 16 gallons:
- White rice (half cup): 25 gallons.
- Gasoline (refine one gallon): 44 gallons.
- Milk (eight fluid ounces): 48 gallons.
- Egg (one): 63 gallons.
- Almonds (one ounce): 80 gallons.
- Yogurt (one cup): 88 gallons.
- Wool (one pound): 101 gallons.
- Sunday newspaper: 150 gallons.
- Cantaloupe (one melon): 160 gallons.
- Chicken (one drumstick): 330 gallons.
- Steak (eight ounces): 1,232 gallons.
- Hamburger, fries and a soda: 1400 gallons.
- Jeans (one pair made of cotton): 1800 gallons.
- New car, including tires: 39,000 gallons.
- Thanksgiving dinner (eight people): 42,000 gallons.
- Steel (one ton): 62,600 gallons.

Water Conservation Suggestions

TOILET: People use more water flushing the toilet than doing anything in the home.

- Don't use the toilet as a wastebasket.
- Save water on each flush by displacing water in the toilet tank with a quart-size plastic bottle filled with water and pebbles/small rocks for weight.
- Invest in a low-flow toilet (several gallons per flush can be saved).
- Check for leaks and repair any found. Make sure the rubber flapper in the toilet tank is forming a proper seal so the tank will fill for the next flushing. An improper seal can waste 40,000 gallons of water per month.

BATH AND SHOWER:

- Take showers instead of baths.
- Take shorter showers.
- Install water saving showerhead or flow restrictor.
- Fill the tub only part way when bathing.
- Turn off water while soaping up in the shower and turn it back on to rinse off.
- Recycle bath water by using it on house plants.
- Don't waste cold water while waiting for hot water to reach the showerhead. Catch the cold water in a container and use it to water plants or flush the toilet.

SINK: Don't let water run down the bathroom and kitchen sink unnecessarily.

- Turn off the water while brushing your teeth. 2 to 4 gallons a minute are wasted if the tap is left on.
- Wash fruits and vegetables in a bowl instead of under running water.
- Don't wait for running water to get cold before having a drink. Instead, keep a container of drinking water in the refrigerator.
- If you wash dishes by hand, don't let water run while rinsing. With two sinks, fill one with soapy water and the other with rinse water. If you only have one sink, use a spray device or short blasts instead of letting the water run.

APPLIANCES:

- Invest in water efficient dishwashers and washing machines.
- Wash only full loads of dishes or clothes. Use low-volume setting.
- Save water by using a dishwasher rather than doing dishes by hand. An automatic dishwasher uses 9 to 12 gallons of water while hand washing can use up to 20 gallons.

GENERAL HOUSEHOLD AND GARDEN:

- Do a home leak-check on all faucets, and water lines to appliances. Make repairs.
- Water grass and other plants during the early morning or evening hours when temperatures and wind speeds are the lowest. Reduces evaporation.
- Place a layer of mulch around trees and other plants to retain moisture.
- Use drip irrigation lines to water the garden, orchards and shrubs.
- Landscape with drought tolerant or native species of plants.
- Always use a nozzle on a hose so the water can be easily shut off.
- Sweep walks and driveways, instead of hosing them.
- Wash the car with bucket and suds. Use hose only when rinsing.

Post-Site Activity
Community Forum
(The Great Debate)

Summary
Students, through a community forum scenario, debate issues relating to water use and water politics.

Time: 60 to 75 minutes.
Setting: Classroom
Materials: Five tables, enough chairs for each student, masking tape, permanent marker (sharpie), white sheets of paper, pencils, watch with a second hand, and a gavel or another type of sound "inducing" device for the moderator.
Goals and Objectives: IC, IIA, IIC, IIIB, IIIC and IVA
California Curriculum Standards: Science 6h. Listening and Speaking 1.1 thru 1.7

Volcabulary: Debate, constructive speech, and rebuttal speech.

Background: A debate is a discussion involving opposing viewpoints. Debates are often held in public forums as a way for members of a community to come together to discuss important issues in a formal setting. Debates involve two kinds of speeches: constructive and rebuttal. Constructive speeches support a viewpoint, while rebuttal speeches try to disprove or discredit a viewpoint by offering opposing arguments. The viewpoints expressed with both constructive and rebuttal speech needs to be supported by evidence.

Around the world issues related to water are being debated. Most of these debates concern where water should go, who gets the water and how much they should get. Each water resource issue involves individuals trying to resolve a problem. Concerned parties, such as resource managers, citizen groups, business people or agricultural representatives meet and debate to have their interests heard with the hope that their solutions will be enacted. Because water is an essential resource to all people and life, community discussion on how to use it is important.

Activity

Preparation

1. Set-up five tables in a circle (four for the interest groups and one for the moderator). Note: Four interest groups are used because this divides up the class well – roughly eight students per group. Place the needed chairs in a semi-circle around the outer edge of the tables (circle).
2. On the inner edge of each table, display the name of the interest group.
3. Have paper and pencils at each table for interest groups to take notes, especially important for the rebuttal portions of the debate.
4. Have a gavel or other device to help the moderator keep order (important for controlling the time each group is given to make a statement).

5. A watch with a second hand is needed.

Introduction: Introduce debate topic to the class. Discuss premise, **Debate Scenario**, and assign interest groups (four). At the end of the introduction, the students will no longer be students but advocates or spokespersons for their group. Even if they don't agree with the position of their group, it's important that they role play, become "devil's advocates" to the cause. Give each group a **position card** explaining the point of view they will take during the debate (they'll read this card as a group during preparation for opening statements). Have each group pick a person to give the opening statement. The teacher or ranger will be the moderator, presiding over the debate by keeping order and track of time. The more formal the moderator is about his or her role the more serious the students will be about their own. **5 minutes needed for introduction**

Opening Statement Preparation: Each group will have **15 minutes** to prepare for the debate. The time should be used to read position cards and strategies. Pencil and paper is used to jot down notes, to write points that will help strengthen an interest group's argument. Students should be encouraged to be imaginative, to come up with ideas not specifically mentioned in the position cards to make their case. One individual from each group needs to be selected to give an opening statement. The four groups should separate in the classroom as they prepare their opening statements.

Debate

1. The moderator welcomes debate participants and stresses the point that this is an open forum. The forum is an opportunity for various interest groups to express their opinion on the topic at hand. **1 minute**
2. Each group presents a two minute opening statement. The moderator needs to tell each spokesperson when they have thirty seconds left. Cut them off if they are not finished. **8 minutes**
3. After opening statements are completed, the groups have an opportunity to present a one minute rebuttal. One person from each group is selected to give the rebuttal (jotted notes taken during opening statements will help the person giving the rebuttal to better articulate their views and challenge their opponents). **4 minutes**
4. The debate portion of the open forum begins after rebuttals have been given. By raising their hands and waiting to be called upon by the moderator, any representative from a group can challenge another group on their position. Challenges can either be made with a statement or direct question. Representatives will not talk over each other but instead patiently wait to make their statement or ask their question on behalf of their group when called upon. **20 minutes**
5. Following the debate, each group has two minutes to make a closing statement. Someone from within the group is selected to do this (ideally it should not be the same students that gave the opening statement and rebuttal earlier in the forum). **8 minutes**
6. The open forum ends with the moderator thanking the groups for their participation. No decision concerning the issue will be made today (no winner or losers at the end of the debate). Debate participants can be informed that the issue will be resolved at a later date.**1 minute**

Debate Scenario: A dam has been proposed for construction on a nearby creek. There are members of the community that support the dam's construction while others are against it. To help address public concern, a community forum has been called by the Bureau of Reclamation, the federal agency responsible for building the dam.

Position Cards

Moderator: Bureau of Reclamation
As a representative of Reclamation, your agency is interested in public opinion concerning the merits of the dam's construction. It is your responsibility to listen to groups that are for and against the dam being built. Eventually, a decision will be made on the issue. For today, however, your agency is listening to different viewpoints.

City Council Members
As members of the city council, you have proposed that the creek be damned. The damning of the creek would create a reservoir that would help the city store water in times of drought. The stored water would be used both by city residents in their homes and by local farmers to grow food. Note: The Happy Boater's Association also wants to see the dam built.

The Happy Boater's Association
As representatives of the Happy Boater's Association, you think it's a great idea to build a dam. The dam would make a reservoir (lake) that people could use for recreation. Boating and fishing are just two of the many activities the reservoir could be used for. In addition, the reservoir would be great for the local economy - jobs would be created and money made! Note: The City Council also wants to see the dam built.

Woodsy Outdoor School
As students of Woodsy Outdoor School you think it would be a disaster to build a dam on the creek. For years, students from Woodsy have learned about nature along the creek. The dam would create a reservoir (lake) that would drown-out the school and change the environment forever. All the nature along the creek is too important for the students of Woodsy to loose. Note: The Conservation Club also does not want to see the dam built.

Conservation Club
As members of the Conservation Club you think it is important to protect the creek and conserve water. You feel the dam would not only destroy the natural environment but also the human history of the area. You are also worried about the rare Seven-Spine Stickleback Fish that lives only in the creek and is found nowhere else in the world. In addition, your organization feels that with more water conservation in the community the dam and reservoir would not be needed. Note: The Woodsy Outdoor School also does not want to see the dam built.

Discussion Points

- Did you agree with the position of your interest group or were you just acting?
- Is it possible to reach a compromise in water related issues? Does there always have to be a winner and looser? Is it possible to find a "middle ground" with the issue debated here?
- What debate strategies or techniques worked well (and which did not work)? Why is it important to be able to present an argument clearly? Are examples and facts (evidence) important when making an argument? What sort of facial expressions and gestures are useful when communicating?
- Can water conservation, treatment and recycling extend the amount of water already available or is finding new sources of water always necessary for communities to grow and prosper?

Extensions

1. Write and present a speech expressing an opinion about a water-related issue in the community.
2. As a class brainstorm a list of water topics that are characterized by two opposing viewpoints. Discuss the pros and cons of each viewpoint.

Post-Site Activity

Scientific Method

(Parts of this lesson have been adapted from the "Urban Creek Observations" activity of the Kids in Creeks program of the Aquatic Outreach Institute)

Summary
Students will use the scientific method to explore water quality issues as a follow-up to the "Lake Detective" activity.

Time: 50 minutes
Setting: Lake, pond, creek or river
Materials: "Water Study Field Journal", "Water Temperature Chart", "Water Color/Water Odor Chart", "pH Chart and Scale", pencil, a clear plastic container and a thermometer.
Goals and Objectives: IIA, IIB, IIC and IIIA
California Curriculum Standards: Science 6a, 6b, 6c, 6f, 6g and 6h. Math (number sense) 2.4 and 2.5. Math (mathematical reasoning) 1.1 and 1.2.

Vocabulary: Scientific method, hypothesis, observation, variable and data.

Background
The scientific method is the way scientists learn about the world. It can be used to study anything from a water bug to the entire universe. The basis of the scientific method is asking questions and then trying to come up with answers. You could ask, "Why is the water green?" An answer might be; nutrient pollution has caused an abundance of algae grow. BOOM! This is the first two steps of the scientific method in action.

The scientific method generally involves four steps:

1. **Observation.** Observations are used to develop a question. The question should be about what you are interested in learning or what you want to know. For example, why is the water green?
2. **Hypothesis.** A hypothesis is an explanation for the observation. It's a "best guess" or a prediction that can be tested. For example, nutrient pollution has caused an abundance of algae growth.
3. **Test Hypothesis.** Information (data) is collected through experiments or further observation to either prove or disprove the hypothesis. The process of gathering information is objective, in other words, it's based on factual evidence not emotions or feelings. For example, an experiment would be conducted to see if nutrient pollution is actually causing all the algae to grow.
4. **Conclusion.** The conclusion determines the validity of the hypothesis. Depending on the information collected, the hypothesis will either be supported or will not be supported. The conclusion is based on objective analysis of the data collected. For example, experimental data shows high levels of phosphates in the water has contributed rapid algae growth. The conclusion in this instance has confirmed the hypothesis.

Scientists work hard to come up with answers to questions. The trick is to be able to prove every answer. If an answer can't be tested, other scientists can't prove it to see if it's right. However, when an answer has been tested and confirmed, other scientists can learn things from what has already been proved. This is what makes science special: It builds on what has already been learned to be true. For example, you will never have to prove that water (H_2O) is made up of one oxygen (O) and two hydrogen (H) atoms – somebody has already proven that fact. Scientist use previous knowledge to make new observations and to answer new questions.

Activity

1. Complete the first two steps of the scientific method by examining a local body of water.
2. Select a lake, pond, river or creek near your school or home to study.
3. Use the Water Study Field Journal as a guide to make observations and collect data on several water quality variables (appearance, color, odor, and temperature). See: Water Temperature Chart, and the Water Color/Water Odor Chart.
4. Students will develop a hypothesis or explanation about the water's condition based on their observations.

Discussion Points

- Based on your observations and the data you collected, what can be concluded about the body of water you examined?
- Does your hypothesis include an explanation for the water's condition? Also does your hypothesis make a prediction?
- How could your hypothesis be tested? What future experiments would be needed to either prove or disprove your hypothesis?

Extensions

After formulating a hypothesis, select a water quality variable that is easily tested and measured (i.e. pH or temperature). Collect quantitative data (number values). Use the data to determine the validity of the hypothesis. For example, if your hypothesis states that the absence of fish from a pond is the result of a low pH, use the pH chart and scale (included in teacher packet) to help support or reject the hypothesis. For more information on water quality variables refer to the appendices of the teacher packet.

Water Study Field Journal

Name: _____
Date: _____ Time: _____
County Where Data Was Gathered _____ State: _____
Site Location: _____

You are a scientist. The job you have is to investigate water quality. To learn about water you need to collect information, also known as data, by making careful observations and answering important questions.

Find a lake, pond, river, creek or another type of water body near your home or school. To complete the activity you will need this **Field Journal**, pencil, a clear plastic container and a thermometer.

The questions in the Field Journal marked with an (*) may be answered back in the classroom using the **Water Color/Water Odor Chart** and the **Water Temperature Chart** (your teacher has copies of both of these charts).

Lake Appearance
Look at the water you are studying. How would you describe the water? Check one or more of the following boxes.

- ☐ clear
- ☐ muddy (brown)
- ☐ cloudy/turbid (not clear)
- ☐ trashy
- ☐ foamy (Is there foam on the water?)
- ☐ pea soup like (green)
- ☐ colored sheen (oily / see rainbows)
- ☐ other (_____)

Name two things you see on the land that might affect how the water looks?

Water Color Test
Follow the steps:

1. Use a clear, plastic container to collect a sample of water.
2. Inspect your water sample in the light against a white piece of paper (this journal).
3. Check the box that best describes the color or appearance of your water.

- ☐ Green, Green-Blue, Reddish Brown or Red
- ☐ Light to Dark Brown
- ☐ Rainbows on Surface (oily sheen)
- ☐ Foamy
- ☐ No Unusual Color

*Use the **Water Color Chart** to answer the following questions. What might **cause** your water sample to have a certain color or look?

_____

Water Odor Test

Follow the steps:

1. Collect a fresh sample of water.
2. To test the odor (smell) of the water, use your hand to wave the air above the water sample towards your nose.
3. Circle the best answer. Is the odor of your water sample:

Very Strong Strong Faint I Don't Smell Anything

4. Check the box that best describes the odor of your water sample.

- ☐ Musky (decomposing straw, damp cellar smell)
- ☐ Harsh (stale sewage, dead algae smell)
- ☐ Sulfur (rotten egg smell)
- ☐ Chlorine or chemical (swimming pool smell)
- ☐ No unusual smell

*Use the **Water Odor Chart** to answer the following question. What might **cause** your water sample to have a certain smell?

Special note: We all have different senses of smell. No two noses are alike. Maybe you will smell something maybe you will not. In fact, what you smell might be different from what somebody else smells.

Temperature

Water temperature is an important factor for the survival of aquatic life. Record the water temperature by following these steps:

1. Lower a thermometer a couple of inches below the water surface. The thermometer does not need to be completely submerged to take a reading.
2. Keep the thermometer in the water for 1 to 2 minutes.
3. Take the water temperature reading while the bulb of the thermometer is still in the water.
4. Record your reading in both Celsius and Fahrenheit.

_____ Celsius temperature _____ Fahrenheit temperature

To convert degrees Fahrenheit to degrees Celsius use the following formula:

$$(F - 32) / 1.8 = C$$

To convert degrees Celsius to degrees Fahrenheit use the following formula:

$$(C \times 1.8) + 32 = F$$

*Use the **Water Temperature Chart** to answer the following question. Name one natural and one human-related **cause** for water temperature change?

_____

*Name an **effect** water temperature has on aquatic life (hint: look in **Water Temperature Chart**)? _____

Hypothesis

A hypothesis may be thought of as a well-informed guess that is drawn from a collection of ideas. It provides a "starting point" for explaining certain facts or observations. Hypothesis example: Pollution has caused a lot of algae to grow in the water.

Based on your initial observations, write a possible hypothesis on the quality of the water you have examined. _____

_____

_____

WATER COLOR CHART

Water Appearance	Possible Cause
Green, Green-Blue, Brown or Red	Indicates the growth of algae, which might be caused by high levels of nutrient pollution. Nutrient pollution can come from organic wastes, fertilizers, or untreated sewage.
Multi-Colored (oily sheen)	Indicates the presence of oil or gasoline floating on the surface of the water. Oil and gasoline pollution can be caused by mining, leaks in fuel lines and fuel tanks, boat waste, and runoff from roads and parking lot surfaces.
Light to Dark Brown	Indicates high levels of suspended sediment (soil), giving the water a muddy or cloudy appearance. Erosion is the most common source of high levels of suspended sediments in the water. Land uses that cause soil erosion include mining, farming, construction, and unpaved roads.
Foam	Excessive foam is usually the result of soap or detergent pollution. Moderate levels of foam (more likely for Lake Berryessa) can result from the decay of algae, which indicates nutrient pollution.
No Unusual Color	Not necessarily an indicator of clean water. Many pesticides, herbicides, chemicals, and other pollutants are colorless or produce no visible signs of contamination.

WATER ODOR CHART

Odor (smells like)	Possible Cause
Musky	May indicate the presents of sewage discharge, livestock waste, decaying algae, or decomposition of organic pollution.
Harsh	May indicate the presence of industrial or pesticide pollution.
Sulfur	May indicate the presence of organic pollution, such as domestic or industrial waste.
Chlorine or Chemical	May indicate the presence of over-chlorinated discharge from a sewage treatment facility or a chemical industry.
No unusual Smell	Not necessarily an indicator of clean water. For example, many pesticides and herbicides from agricultural runoff are colorless and odorless.

WATER TEMPERATURE CHART
(Factors that Affect Water Temperature)

Cause	Effect
Energy from the Sun	Seasonal and daily changes in sunshine and air temperature affect water temperature. Different species of aquatic organisms need different water temperatures to reproduce. For example, some species of fish are warm water breeders while others breed only in cold water.
Depth of Water	Water temperature will change with water depth. Deeper waters are usually colder. However, bottom and surface waters can mix during the year. This mixing of different temperature waters helps to provide nutrients and oxygen to aquatic organisms throughout the lake.
Removal of Plants	Removing vegetation, like trees, from around water reduces shading and can lead to increased water temperatures. This is especially true along rivers and creeks. The shading and cooler waters are preferred by many fish.
Soil Erosion	Sediments not only affect the appearance of water but they also change the temperature. Suspended soil sediments absorb heat causing the water temperature to increase.
Inflow and Outflow Points	Water from different places mix (i.e. stream to a lake).

WATER TEMPERATURE and FISH
Temperatures are given as ºF (ºC)

[Above the stated temperature *]

Fish species	Optimum temp	Fish Will not spawn (breed)	Fish Embryos die	Fish Growth stops	Fish die
Black Crappie	---	63 (17)	68 (20)	81 (27)	---
Bluegill	---	77 (25)	93 (34)	90 (32)	95 (35)
Brook trout	---	48 (9)	55 (13)	66 (19)	75 (24)
Carp	90 (32)	70 (21)	91 (33)	---	97 (36)
Channel Catfish	---	81 (27)	84 (29)	90 (32)	95 (35)
Large Mouth Bass	74 (23.5)	70 (21)	81 (27)	90 (32)	93 (34)
Rainbow Trout	55 (13)	46 (8)	59 (15)	66 (19)	75 (24)
Small Mouth Bass	---	63 (17)	73 (23)	84 (29)	---
Sockeye Salmon	59 (15)	50 (10)	55 (13)	64 (18)	72 (22)

Vocabulary and Definitions

Adaptation: The special equipment or behavior a living thing has which helps it survive in its environment. For example, plants that grow in the desert have special adaptations that enable them to survive on a reduced water supply.
Agriculture: The changing of land for growing crops and livestock; farming.
Aquatic: Something growing, living in or frequenting water.
Aqueduct: A human-made channel for moving water from one place to another.
Aquifer: An underground, rock-bearing area containing groundwater that feeds wells and springs.
Biodiversity: A term used to represent the variety of life in a given area.
Bureau of Reclamation: A federal agency responsible for managing, developing and protecting water and related resources in an environmentally and sound manner in the interest of the American public. The Bureau of Reclamation manages Lake Berryessa.
Canal: An artificial waterway for navigation or irrigation. For example, farmers cut channels in the land to water their crops.
Condensation: The process by which a vapor becomes a liquid; the opposite of evaporation.
Conservation: The protection and preservation of natural resources. For example, the use of water-saving methods to reduce the amount of water needed for homes, agriculture and industry for long-term social and economic benefits.
Constructive Speech: A speech that supports a viewpoint.
Debate: A discussion involving opposing viewpoints.
Dam: A barrier to obstruct the flow of water, as one built across a stream or river.
Data: Facts, statistics or items of information.
Direct Water Use: Water that is used through immediate actions. For example, flushing a toilet is a direct water use.
Ecosystem: A community of interconnected living and non-living things.
Environment: The total of all the surroundings – air, climate, water, soil, rock, plants, wildlife, human elements that has an influence on you and your existence.
Erosion: The movement of rock and soil from one place to another by forces of water, wind, walking, etc.
Evaporation: The process by which a liquid becomes a vapor; the opposite of condensation.
Ground Water: Water found in spaces between soil particles underground.
Hydroelectric Power: The generation and distribution of electricity produced from the energy of falling water.
Hypothesis: Is a potential explanation for an observation or set of facts that can be tested through further investigation.
Indicator Species: An organism that is especially sensitive to changes in the environment brought on by pollution or other disturbances.
Indirect Water Use: Water not used through immediate actions or consequences. For example, eating an orange is an indirect water use since it took water to grow the orange.
Invertebrate: An animal without a backbone. Insects, spiders, worms and snails are examples of invertebrates.
Irrigation: To supply water to land by artificial means, as by diverting water from a stream into a canal.
Larvae: The young of any invertebrate animal (also can refer to the young of specific invertebrates).

Observation: To watch or note for a scientific or special purpose.
Organism: A living thing.
Oxymoron: A figure of speech that uses seeming contradictions. For example, a "dry lake" is an oxymoron.
Precipitation: Water falling, in a liquid or solid state, from the atmosphere to Earth. For example; rain, snow, sleet, hail and even fog are types of precipitation.
Photosynthesis: The process by which plants make their own food from non-living things like sunlight, air, soil and water.
Pollution: A harmful change in the character or quality of the environment. For example, chemical waste can change a lake by making it dirty and unhealthy.
Rebuttal Speech: A speech that tries to disprove or discredit a viewpoint by offering an opposing argument.
Reservoir: A lake artificially created by damming a stream or river. Where water is collected and kept for a variety of uses, including flood control, water supply, recreation and hydroelectric power. Lake Berryessa is a reservoir.
Resource: A portion of the environment which people have placed value on or see as being available for use.
Runoff: Precipitation that flows overland to surface streams, rivers and lakes.
Sensitive: Something that is easily affected by something else. For example, some invertebrates are very sensitive to water pollution.
Scientific Method: A method utilized in acquiring knowledge and establishing principles pertaining to natural phenomena based on observation and experimentation.
Scientist: A person who gains knowledge of the world through observation and experimentation.
Transpiration: The process by which plants lose water through their leaves.
Tributary: A stream that contributes its water to another stream or body of water.
Tolerant: Something that is not easily affected by something else. For example some invertebrates can tolerate some pollution.
Variable: Something that is inconstant, capable of being varied. For example, temperature is a variable.
Water: An odorless, tasteless, colorless liquid made up of a combination of hydrogen and oxygen. Water forms streams, lakes, and seas, and is a major part of all living things.
Water Cycle: The path water takes through its various states – vapor, liquid, solid – as it moves throughout the Earth's system (ocean, atmosphere, ground water, streams, etc). The water cycle is also known as the *hydrologic cycle.*
Water Quality: How good water is with respect to its suitability to a particular use.
Watershed: The land area from which surface runoff drains into a stream channel, lake, reservoir, or other body of water.
Weathering: The breakdown of rocks into soil by forces such as wind and water.

A Lake Berryessa History

Lake Berryessa is a reservoir, created to provide water for irrigation, municipal and industrial uses and flood control protection. Under the waters of Lake Berryessa lies the Berryessa Valley, a long swath of land once occupied by a town, ranches and farms.

The earliest dwellers of the Berryessa Valley were the Miwok and Wintun Indian tribes who lived on the valley floor along Putah Creek and its tributaries. These Native Americans existed quite comfortably there until the early 1800's when early European settlers slowly forced them to leave the valley floor and settle in the surrounding hills.

In 1843, Mexican Governor Micheltorena signed official grant documents giving brothers Jose Jesus and Sisto Berryessa 36,000 acres of land, which constituted the whole Berryessa Valley. It was one of the largest land grants in California. The Berryessa family constructed a huge adobe hacienda in the center of their property and had thousands of cattle, sheep, and horses on the surrounding acreage. The Berryessa land was later sold to the "Land Company" who parceled the land into farm properties, leaving an area for the development of a town. In 1866, the town of Monticello was founded, and by 1870, there was a general store, blacksmith shops, several hotels and businesses, and a four-horse stage line running from Knoxville to Napa via Monticello. In 1896, the Putah Creek Bridge was constructed across Putah Creek in the center of Monticello. This bridge has the unique distinction of still standing beneath the waters of Lake Berryessa today.

After gold was discovered in California, a vast migration passed through nearby Solano County since it was on a direct route between San Francisco Bay and the gold fields. Communities grew rapidly, and agriculture expanded. Following the severe drought in the 1860's, large-scale grain production began, followed by a more diversified agriculture based on irrigation and dry-land crops. Sheep and cattle production continued to hold an important place in the economy of the area. Specialty crops came into prominence as demand for agricultural products in the San Francisco Bay area increased and water well capability was developed.

Development of Monticello Dam and the Solano Project

With the increased irrigation and the municipal and industrial development of Solano county, the demand for water resulted in the utilization of all of the more readily available sources of supply. The problem of obtaining additional water to maintain existing and planned development became more and more critical. In 1908, the newly formed U.S. Bureau of Reclamation considered a plan to supply water to Dixon and Winters. This plan never materialized and several other ideas came and went until 1947, when Solano County, in cooperation with the Bureau of Reclamation, formed the Solano Project in order to provide water to Solano County and surrounding irrigable lands. The project entailed damming Putah Creek along a narrow gorge and impounding water within the Berryessa Valley. By 1957, the Monticello Dam had been completed, creating Lake Berryessa. Lake Berryessa provides water annually to the cities of Vallejo, Vacaville, Fairfield, Benicia, Suisun and communities in Napa County as well as to thousands of acres of farmland. Water is furnished through the city systems to Travis Air Force Base, Mare Island and Benicia Arsenal. When full (440 feet above sea level) the lake is 23 miles long, 3 miles wide and stores 1,600,000 acre feet of water within the 165 miles of shoreline. The lake provides 207,350 acre

feet of water to the community each year, enough to support 207,350 families, or fill up that many football fields with water a foot deep.

Recreation Development

At the time of the lake's development, the Bureau of Reclamation lacked specific authority and funds to develop and manage recreation facilities. In 1958, Napa County was persuaded to enter into a management agreement for the administration and development of recreation facilities. The Bureau of Reclamation regained management of the recreational uses on and around the lake in 1974. Reclamation added several day use areas for the visiting public that are available today along with other recreational opportunities in the area.

Reclamation provides four free public day use areas; Oak Shores Day Use Park, Smittle Creek Day Use Park, Capell Cove Boat Launch, and a new non-motorized boat launch site at the North end of the lake. The day use areas offer a spectacular view of the lake with picnic tables, barbeque grills, hiking trails, off-shore fishing, and beach related activities. A park visitor center is adjacent to the Oak Shores Day Use Area. Lake Berryessa also offers opportunities for camping, overnight use, restaurants, marinas, and other visitor services in seven resorts that are managed by private concessions under contract with Reclamation.

Water Quality Variables
(Teacher Background Information)

(Variable descriptions can be found within the "Water Quality Testing" and "Urban Creek Observation" activities of the Kids in Creeks program of the Aquatic Outreach Institute)

Appearance: "Beauty is only skin deep" is a familiar adage invoking a person to look beyond the superficial. However, in relation to water quality, much can be learned by the surface appearance alone. The color and overall visual characteristics of water give clues to its condition and what possibly might be causing a contamination. For example, green, green-blue, brown or red color could indicate excessive algae growth resulting from unusually high levels of nutrient pollution. A light to dark brown color, giving the water a muddy or cloudy look, typically indicates elevated levels of suspended sediments brought on by soil erosion. Foam on the surface, a sign of algal decay, can be caused by nutrient pollution or the direct result of soaps and detergents entering the water. Looking at water closely, with an examining eye, helps to determine the type of contamination and what ultimately might be the source of pollution. It's important to remember that the effects of such things as sedimentation are often brought about by poor land management decisions.

Odor: Odor in the water may be due to natural or human causes. Natural causes include the decay of algae or the presence of microorganisms. When organic matter decomposes, gases like ammonia and hydrogen sulfide are given-off, leading to a sulfur (rotten egg) or musky smell. Human caused odors are often associated with sewage, industrial waste and chemical compounds. These smells may be acrid or harsh. In some cases a strong odor has both a natural and human origin. For instance, the decomposition of algae is a natural smell but the amount of it decaying may be the result of excessive growth brought on by untreated sewage. Although odor is generally considered an undesirable trait for water, the lack of a smell does not necessarily mean good quality water. Many chemical pollutants are both colorless and odorless. To determine how healthy a body of water is other factors beyond appearance and odor need to be examined and measured.

Temperature: One of the most important water quality parameters is temperature. It influences:

- the amount of oxygen that can be dissolved in water
- the rate of photosynthesis by algae and other aquatic plants
- the metabolic rate of organisms
- the sensitivity of organisms to toxic waste, parasites and disease, and
- the timing of reproduction, migration, and activity level of aquatic organisms.

Both natural and human factors affect water temperature. Some natural factors include:

- energy from the sun (seasonal and daily changes, shade and air temperature)
- inflow and outflow points (areas where water of different origins mix)
- groundwater infiltration (usually cooler)
- depth of water
- color and turbidity of water (suspended sediment absorbs heat).

Human caused factors contributing to a change in water temperature include:

- removal of plants (reduces shading – particularly in riparian areas)

- soil erosion, and
- storm water runoff.

Variations in water temperature, particularly seasonally, are a natural part of aquatic systems. However, temperature swings beyond expected seasonal ranges do create serious problems. Temperatures generally above 27 degrees centigrade (81 degrees Fahrenheit) and very cold water have disruptive affects on the life history of organism. For example, when a dam is built, water released from it is usually much colder than the original creek or river temperature. One of the consequences of this is that the colder water impacts the reproductive ability of fish species adapted to a warm water environment. In contrast, trout and other cold water species suffer when water temperatures exceed 24 degrees centigrade.

Turbidity: Turbidity is a term characterizing the degree water cloudiness. As light passes through water, it is scattered by suspended sediments. These sediments as well as algae, various types of organic matter and some pollutants can obscure the water and make it more turbid. Natural factors that increase turbidity and decrease water clarity include:

- seasonal weather and storm events that effect run-off and sediment transport
- nutrients cycling within a system
- algae bloom and growth, and
- the specific physical attributes of an area.

Human factors responsible for excess turbidity include:

- erosion due to the removal of vegetation
- increase in non-native vegetation
- construction or other disturbances around a water body
- changes in stream morphology and flow patterns, and
- excessive nutrient loading (dumping) leading to high algal growth.

Increased turbidity can negatively affect water quality. For example, suspended sediments absorb heat and diffuse sunlight raising water temperatures and reducing the light available for algal photosynthesis. Once sediments settle, they can damage fish gills, destroy spawning areas and smother aquatic insect habitat. The sediments themselves can also carry pathogens and pollutants while the excess nutrients brought into the system impact overall water chemistry.

pH: Water (H_2O) contains both hydrogen ions (H^+) and hydroxide ions (OH^-). The relative concentration of these ions determines pH and whether a solution is acidic or basic (alkaline). In pure water the concentrations of ions are equal (a neutral solution). In an acidic solution, the concentration of hydrogen ions is greater than the concentration of hydroxide ions. The opposite is true for a basic solution.

pH is a measure of how acidic or basic (alkaline) a solution is. To determine this, a pH scale from 0 to 14 is used. Each whole number on the scale represents a ten fold difference or increment change (logarithm). It works as followed: For each whole number increase (i.e. 1 to 2) the hydrogen ion concentration decreases ten fold. As pH decreases, water becomes more acidic. For example, a pH of 5 is 100 times more acidic than a pH of 7. As water becomes more basic, the pH increases. A pH reading above 7 is considered basic, while a pH below 7 is acidic. A reading of 7 is neutral.

Many factors affect water pH. Here's some.

- Acid rain and fog: Air pollution from automobiles and industry put sulfur dioxide (SO_2) and nitrogen oxide (NO_2) into the air. These react with water vapor in the air to form sulfuric and nitric acids. When it rains or becomes foggy, these acids get into the water system causing the pH to decrease.
- Sewage: Household sewage has many bases in it which increase the pH of water. The decay of sewage by bacteria can also raise pH.
- Water temperature: higher water temperatures have slightly lower (more acidic) pH values.
- CO_2: The presence of CO_2 affects pH by causing acidity. Natural rainwater is approximately 5.6 due to the presence of CO_2 in the atmosphere.
- Photosynthesis: The process of photosynthesis uses up CO_2 in the water, which makes it more basic during daylight hours.

pH is an important measure of water quality because many plants and animals are sensitive to slight changes in pH. Each species has its own pH range in which it can survive and prosper. In particular, organisms are unable to reproduce and breathe well when the pH becomes very low or high. At the extreme ends of the pH scale, physical damage to gills, fins, exoskeletons and other structures occur. (See pH scale in appendix)

Dissolved Oxygen: Oxygen is found in both the atmosphere and water. When in water it's known as dissolved oxygen. Factors affecting dissolved oxygen (DO) content are:

- Water temperature: Cold water holds more oxygen than warm water.
- Re-aeration: Oxygen from the air is dissolved into water at its surface, mostly through turbulence (i.e. ripples and wave action).
- Photosynthesis: Plants in the water produce oxygen when they photosynthesize.
- Altitude: At higher altitudes, less photosynthesis takes place to create oxygen.
- Respiration: Aquatic organisms breathe and use oxygen.
- Breakdown: The breakdown of organic matter requires oxygen. For example, DO is used up by decomposing bacteria when there is large amounts of dead material around (i.e. from algae blooms).
- Salinity: As salinity increases, DO decreases.
- Mineral content: As minerals increase, DO decreases.

Most aquatic organisms need oxygen to survive and grow. Fish and some aquatic insects have gills to extract oxygen directly from the water. The amount of oxygen available to these organisms is a helpful indication of dissolved oxygen content. For instance, trout and stonefly larvae require high DO whereas catfish, worms and snails do not. If there's not enough oxygen in the water to meet the needs of a particular species, the growth of that species and its ability to reproduce and survive can be seriously impaired. The species present, within a given aquatic system, give clues to DO levels and overall water quality.

Phosphates and Nitrates: Two of the most important nutrients for plant and animal growth are phosphates and nitrates. Both occur naturally in the environment but are readily found as human byproducts. Some of the ways in which they enter water systems include:

- inadequately treated wastewater
- urban runoff
- fertilizer discharge and runoff from agricultural fields
- human and animal waste, and
- the natural weathering of rocks and erosion.

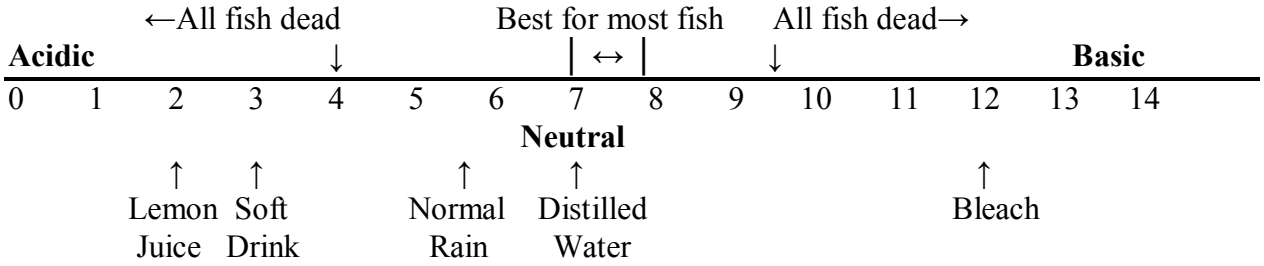
Abnormal levels of nitrates and phosphates entering aquatic systems can greatly accelerate the growth of algae. When the algae die, their decomposition uses oxygen, produces odors and toxins, creates an eyesore and can result in the death of fish and invertebrates. Ingestion of water with high levels of nitrates can also pose a health risk to people and livestock.

pH Chart
(Factors that Affect Water pH)

Cause	Effect
Acid Rain and Fog	Air pollution from automobiles and industry put sulfur dioxide (SO_2) and nitrogen oxide (NO_2) into the air. These pollutants react with water vapor in the air to form sulfuric and nitric acids. When it rains or becomes foggy, these acids get into the water system causing the pH to decrease.
Sewage	Household sewage has many alkaline substances in it that increase the pH of water. The decay of sewage by bacteria can also increase pH.
Water Temperature	Higher water temperatures have slightly lower (more acidic) pH values.
Carbon Dioxide (CO_2)	The presence CO_2 affects pH by causing acidity. Natural rainwater is approximately 5.6 due to the presence of CO_2 in the atmosphere.
Photosynthesis	The process of photosynthesis uses up CO_2 in the water, which makes the water more alkaline during daylight hours.

pH Scale

Effects in Nature



Common Liquids

Pre / Post Assessment
Answer Sheet

1. C
2. B
3. A
4. B
5. B
6. D
7. B
8. A
9. D
10. D
11. E
12. C
13. A
14. D
15. B
16. T
17. T
18. F
19. T
20. T
21. F
22. T

PROGRAM EVALUATION

Thank you for participating in the Lake Berryessa Water Education Program. We know how valuable your classroom time is, and we want to ensure our curriculum and programs are serving your needs. To help us accomplish this, please take a few minutes to complete this evaluation form. Please be as specific as possible and give detailed comments on both the things that worked for you and things that you would change in all aspects of this program. Thank you for your input!

Name of School:
School Address:
Teacher's Name(s): Grade Level:
Program/Location in park: Date of Visit:
Name of Ranger(s):

How did you learn about this program?

Was the reservation system convenient for you? Yes No Suggestions:

Did the program packet provide all the information you needed to prepare for the field trip? Yes No Suggestions:

What pre-site materials did you use? Pre-site activities did you complete? Suggestions for pre-site activities:

Please comment on strengths and weaknesses of the on-site program, presenters, and any methods or materials used.

What post-site materials and activities did you use? Suggestions for post-site activities:

What was the best part of the educational experience for you? For your students?

Please list any additional teachers with their addresses or phone numbers that you would like us to send program information to:

Please circle your response to the following questions:
1 (high/agree) 2 (medium/OK) 3 (low/disagree)

Overall Evaluation

Usefulness from a curriculum standpoint	1	2	3
Quality of program content	1	2	3
Interest level of students	1	2	3
Age appropriateness	1	2	3
Usefulness of pre-site materials/activities	1	2	3
Usefulness of post-site materials/activities	1	2	3
I plan to attend this program in future	1	2	3
I would recommend this to other teachers	1	2	3

On-site Program

Activities relevant to curriculum	1	2	3
Suitable activities for class size	1	2	3
Appropriate program length	1	2	3
Good content for age group	1	2	3
Quality of presenter	1	2	3
Interest level of students	1	2	3

Any additional comments or suggestions? (Feel free to attach any activity suggestions or other materials that you feel would improve this program)

Please return to Lake Berryessa Water Education Program, Lead Interpretive Park Ranger, 5520 Knoxville Road, Napa, CA 94558.

Acknowledgements

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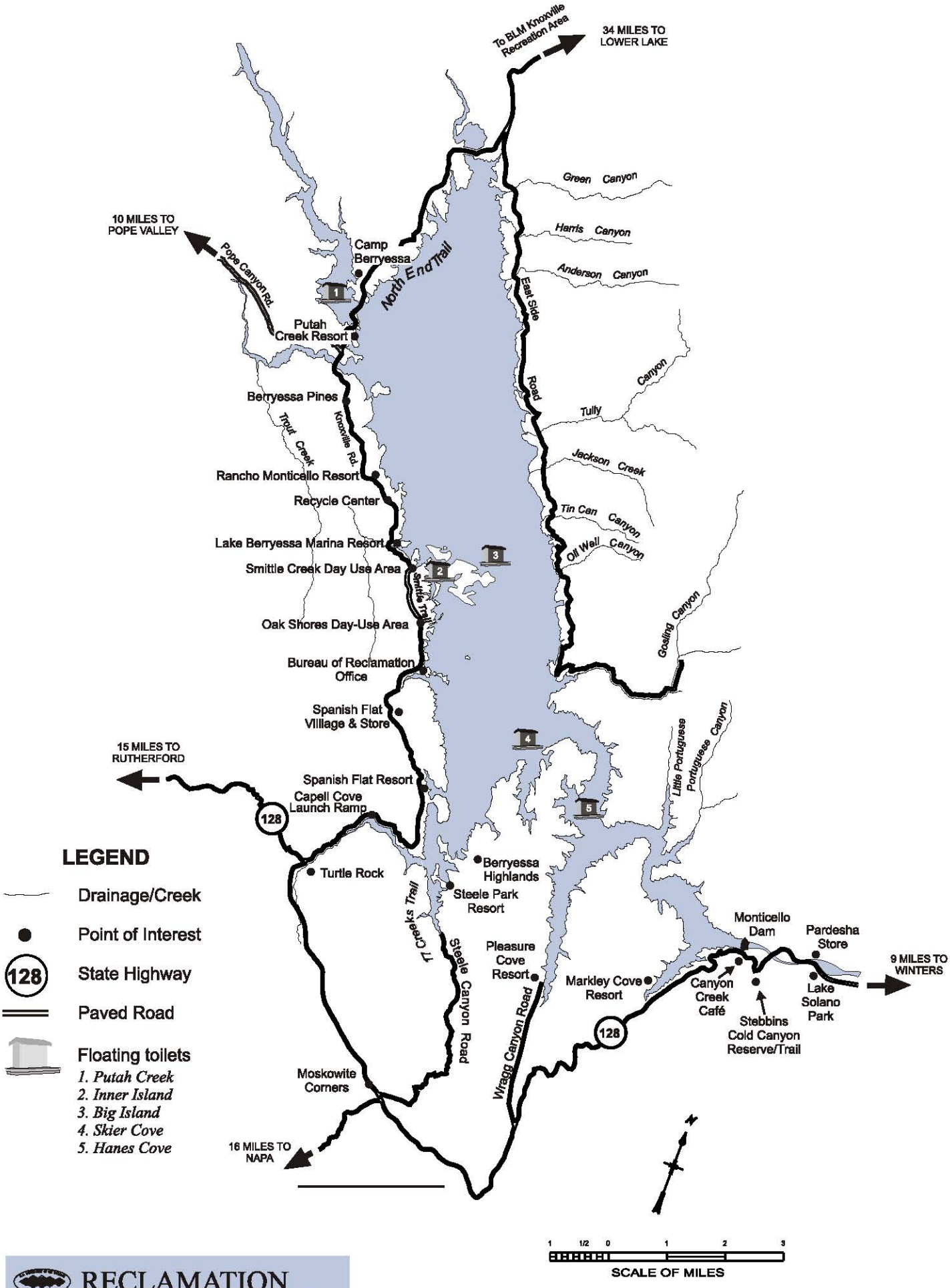
An educator seldom has to reinvent the wheel when preparing a program or lesson. With this in mind, acknowledgement to the following Publications and Institutions is made:

- *Project WET Curriculum and Activity Guide* (The Council for Environmental Education)
- *Kids in Creek - An Interdisciplinary Creek Exploration Program* (Aquatic Outreach Institute)
- *The California State Environmental Education Guide* (Alameda County Office of Education)
- *Project Wild K-12 Activity Guide* (Western Association of Fish and Wildlife Agencies and the Council for Environmental Education)
- *Earth's Water and Weather - A 5th Grade Module Designed To Meet California Science Standards* (Capitol Region Science Cadre)

- *Environmental Education in the Schools* (U.S. Peace Corps)
- *Managing Lakes and Reservoirs* (North American Lake Management Society)
- *Captain Hydro*(East Bay Municipal Utility District)
- *A Water Awareness Program* (The California Water Awareness Campaign)
- *Water Watchers* (Massachusetts Water Resource Authority)
- The California Department of Water Resources
- Colby Outdoor Science School, Los Angeles Unified School District.



RECLAMATION
Managing Water in the West

Lake Berryessa Federal Recreation Area

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region